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Morning Session, Tuesday, January 1, 1924

The meeting was called to order at 10 a. m.

PRESIDENT A. G. RUGGLES: The first papers on the program this morning will be a symposium on "Methods of Estimating Insect Abundance and Damage."

STATISTICAL METHODS IN ENTOMOLOGY

By J. A. HYSLOP, *Washington, D. C.*

ABSTRACT

Entomological survey work has passed the stage of guessing and the biometric method must now be inaugurated in order that the great mass of data being collected by the increasing number of observers may be interpreted. The immediate problem is to establish a standard set of units in entomological survey work and the second problem is to establish the range and type of insect dispersal.

A year ago, before the collaborators of the Insect Pest Survey and the extension entomologists, I outlined the functions, as I conceived them, of the Survey. I wish here merely to re-state its ultimate objectives;

First, to prepare an atlas of our insect pests, not merely distribution maps, broadly blocking in the extreme distribution records, but a weighted map of each species indicating the optimum zone, range of injurious records, and extreme distribution;

Second, to obtain each year as complete an insect census as possible;

Third, to correlate the above data with known variables, to determine the factors which limit insect dispersal and abundance, and,

Fourth, from these determined correlations to lay the basis for insect forecasting.

The title of the subject chosen for this year's symposium is, in one

sense, fortunate and, in another sense, rather unfortunate. By a broad use of the word "estimating" we have drawn the fire of the statisticians.

In the Survey's work it has become increasingly more evident that the estimates we are receiving from our collaborators lose much of their potential value in that; (a) they are not based upon sufficient nor detailed enough observations and (b) that each reporter is forced to adopt original methods of estimating insect abundance which are usually not comparable with the estimates of other collaborators. I do not wish to be construed as criticizing our collaborators as we have gained much in the past three years of the Survey's work in locating the areas of intense damage of many of our more important insect pests and wish our collaborators to continue to send in miscellaneous observations of insect abundance as there is still much to be done along this most profitable line, and it is probably the only line which we can pursue to advantage with our limited funds and organization, but the ultimate object of the Survey is to use this mass of data in statistical entomology and, in order that it may be used for this purpose, it must meet with the requirements of the statistician, that is, the requirements of mathematical common sense.

I wish to digress here for a moment to impress upon you the ridiculousness in carrying out figures in reports which are arrived at by statistical methods to such a point that they indicate the most accurate mathematical precision. An amusing report was recently brought to my attention which eminated from a fish hatchery and gave, after a wordy report, figures similar to the following: indicating that during the past year 13,280,642 fish and fish eggs had been distributed by the hatchery.

We do not wish to perpetuate the old inductive method whereby an entomologist, by virtue of his experience and familiarity with the subject, would go into the field and estimate (in the sense of guess) at the percent of damage being done or the relative number of insects present. These guesses were more or less accurate, usually less, but, even if we disregard the personal equation, they are absolutely useless for statistical work. Even a so-called statistical survey on insect abundance, arrived at by actual count of presumed sample units, is often based on counting and calculating processes and samples which introduce not only a possible error but a probable error, which is greater than the results obtained.

One of the most important things that we will have to pre-determine in this work is a definite standard of accuracy and every record should be brought up to this standard. The data which we use must be based

upon accurate count of adequate samples beyond that point where the probable error is less than the results obtained. The ascertaining of what is an adequate sample is far less simple than it might seem to the casual observer. There is no established correlation between insect abundance and unit areas; a gregarious insect of sedentary habits might easily be conceived as always remaining near its place of origin or introduction. Samples taken at any point in this place bear no relation to the contiguous uninfested territory. It would be an evident fallacy to take the estimated number of gipsy moths in the infested part of the United States (Ma) and divide this by the total area to get the average infestation for the United States and then apply this figure to Georgia as the infestation in Georgia is 0. Many other cases will be extremely difficult: observation on the abundance of an insect that moves with the wind will bear no definite relation to the total area surveyed unless its point of origin in that area is located and the samples taken with respect to that point. These, and many other factors, which introduce biased conditions must be worked out by the investigator. I believe that we could profitably spend much time in the next few years in investigating intensively the dispersal of given pests on given crops as only in this way can we ascertain what constitutes an adequate sample

This will involve selecting an area such as an orchard, a wheat field, a cabbage patch, etc., small enough to be completely examined in a time short enough to eliminate the factor of time distribution of the pest involved. This area will then be divided into units as small as is reasonably measurable as 1 apple tree, 1 cabbage plant, a square foot of alfalfa, etc.

Counts are then made of each unit in the area to be surveyed and mapped. This will bring out trends, such as a constant diminishing in number of insects from high to low side of field, with and against the wind, on different soils, etc., and will probably necessitate subdividing the original area.

Now an analysis of the data should show the point where a frequency of observational units picked at random over the area will reduce the probable error to a negligible factor. By repeating this experiment a number of times this adequate sample should become fixed under similar conditions.

These basic investigations, of course, will take years so our immediate problem as I see it is to adopt, as far as possible, uniform unit samples. For example; future investigation may indicate that 1 per cent of the trees in an orchard will give an adequate sample for codling moth if all

the fruit of each tree in the sample is counted, cut open and the number of infested apples determined. While we are waiting for this determination it is advisable that we all make similar counts no matter how extensive. If but one tree is examined and we use all the fruit and count all the infestation, the data may be useful but if one worker counts but 5 apples per tree or 100 apples picked at random from several trees, and another worker bases his figures on the relation of packing house culls to total crop the figures are practically incomparable.

If a unit Hessian fly sample is to be 10 plants or a square yard it is advisable to have this unit established arbitrarily even though the necessary frequency is still under investigation.

This symposium and the discussion will at least focus the attention of entomologists upon this most important phase of entomological work. Future observational work for statistical data will lack much of its potential value until we have a general realization of the importance of these factors. With their appreciation we should eventually be able to codify the necessary mass of data and the type of data necessary in estimating the abundance and damage for any of our more important insect pests.

METHODS OF ESTIMATING ABUNDANCE AND DAMAGE CAUSED BY THE GIPSY MOTH

By A. F. Burgess, *Melrose Highlands, Mass.*

Abstract

The methods of securing information on the abundance and damage caused by the gipsy moth, *Porthetria dispar* Linn., are detailed for the purpose of indicating the means that can be used to secure information on a single brooded tree-defoliating insect. Detailed information was secured from different areas and in different types of forest growth.

The abundance and destructiveness of any insect depends not only on the rate of increase but on the ability of the species to overcome such impediments as unfavorable climatic conditions, natural enemies and other retarding agencies.

If all factors are properly balanced the insect exists but causes small economic loss. A pest such as the gipsy moth, *Porthetria dispar* Linn., is not perfectly adjusted to its environment either in this country or in its native home and a study of its increase under field conditions is of great importance. The methods used are doubtless somewhat original and may be found of value when similar studies are made on other pests.

The eggs of the gipsy moth are deposited in a single cluster and can be

readily found by anyone experienced in controlling this insect. The caterpillars feed on most deciduous and some coniferous foliage and the female moths do not fly.

From the foregoing statement it would appear that this insect was an ideal subject for making a study of the rate of increase in the field and the damage resulting from its work. The importance of having accurate data along this line was such that preliminary work was begun in 1911 and an intensive study was taken up in 1912. Data have been collected during each year since that time, although the methods of securing the information have been modified as experience on the work and the discovery of new information made changes advisable.

The question of increase of an insect cannot be solved satisfactorily by laboratory methods or theoretical computations. It is necessary to secure the data in the field under normal natural conditions. The two main purposes covered by the experiment was to determine the rate of increase and factors affecting it and the damage resulting from defoliation. The methods used will be considered separately. They are not intended for the use of observers who desire to report on conditions covering a large area such as a state or group of states but for securing reliable data relating to what is actually happening in the field.

Selection of Observation Points

Two hundred and fifty areas in the infested region in Maine, New Hampshire and Massachusetts were selected. These were in different mixtures of forest growth and where different degrees of infestation were present. A central tree was selected which was bounded by a circular area with a radius of 50 feet, making each area about one-fifth of an acre. Each point was numbered and detailed records have been kept since the experiment started.

Each tree in an observation point over 3 inches in diameter was numbered consecutively about breast high with white paint, the highest number being placed on the north side of the center tree. All numbers faced toward the latter tree. The undergrowth which was unnumbered was listed according to species.

Method of Collection of Data on Increase

Counts of all egg clusters in each point were made during the fall. This necessitated climbing the trees and an examination of the litter on the ground as eggs are frequently deposited in such situations. This

work required the services of about 25 men for 3 months and the data was recorded and classified on special forms prepared for that purpose. The egg clusters were rated as large, medium or small at the time of counting so that it was possible to determine rather accurately the potential crop of caterpillars for the next season. In badly infested points hundreds of egg clusters were frequently found on a single tree so that the time required for making an accurate count was considerable. Test collections of eggs and caterpillars were made just outside the points to determine the effect of parasitism on the increase. These were examined or reared at the Laboratory and the rate of parasitism computed.

During the summer the points were visited and information secured on the abundance of disease and its effect on the increase of the species. In order to obtain more accurate data on what was actually happening in the field several points were selected and after careful counts of egg clusters had been made the ground beneath the trees was covered with canvas mats. These were examined daily and all caterpillars that dropped were examined and the causes of death determined and tabulated. The mats required almost constant attention in order that the number of dead larvae might be recorded before they were carried away by ants or other insects. Later a census was made of the condition of the trees as to mortality of caterpillars or pupae, the amount of defoliation and the next brood of egg clusters.

Experience showed that these methods failed to give accurate results principally because a considerable proportion of the small caterpillars were blown from the areas if winds were favorable during the spring and this affected the count records for the following year. In cases of over population and where defoliation resulted many of the large caterpillars migrated for food. If the temperature was too severe in the winter many of the egg clusters that were unprotected by snow or ice failed to hatch.

This caused a modification of the plan which resulted in less stress being placed on the actual number of egg clusters in the points and more on the result of feeding by the caterpillars.

Check records of trees that were actually climbed and those where the infestation was estimated after a partial count made from the ground by men having long experience in this particular work, showed that reasonably accurate data could be secured and much time could be saved. The method was changed accordingly and what is known as an estimate count of each tree replaced the plan at first used. The records have been kept as heretofore.

Method of Collection of Data on Damage

The same trees on which records were kept in the observation points were under observation during the years mentioned in order to determine the damage that was resulting from defoliation. Nearly all the species of forest and shade trees common to New England were included in these areas. Each tree was rated at the beginning of the experiment as either good, fair, poor or dead, based on the condition of foliage and apparent vitality of the subject. Annual records were made in July of the percent. of defoliation of each tree and later in the season its condition was rated.

Three men were ordinarily used on this work. The man in charge of the party kept the notes while the other two made the ratings. Each tree was rated separately by each man and the tally was averaged. Ratings on the percentage of defoliation or condition of the trees are difficult to secure accurately. By averaging the ratings of two or more men data that was more dependable was obtained.

During the ten years that this experiment has been under way many of the trees have been defoliated and have died. In some cases the owners have desired to salvage the areas in which the observation points were located and this has resulted in clean cutting operations.

About one-half of the points have now been cut or it has been necessary to abandon them because practically all of the trees have died.

Damage by the Gipsy Moth is not confined to the actual killing of trees. There are many cases where trees are partly defoliated and suffer retardation of growth from this cause.

Increment borings of typical trees have been secured and the specimens studied to determine the loss in annual growth that results.

An immense amount of data on the abundance and the damage caused by the Gipsy Moth has been secured and will be prepared for a detailed publication later. The foregoing is only a brief outline of some of the methods used.

THE USE OF BIOMETRICAL METHODS IN THE INTERPRETATION OF CODLING MOTH EXPERIMENTS

By F. Z. Hartzell, *Vineyard Laboratory, Fredonia, N. Y.*

Abstract

In this paper, the use of statistical methods in the analysis of data of codling moth, *Carpocapsa pomonella* Linn., experiments and the manner of determining the degree of confidence that can be placed in the results are described. The importance of defining the region to which the results of the field tests apply, of selecting typical

orchards, and of measuring the homogeneity of the experimental areas is stressed. Ths usual methods of measuring variation are described and illustrated by experimental data, special attention being paid to the calculation of the probable error of a mean and standard deviation when the number of trees in a plat are less than 16. The influence of numbers on the confidence that can be placed in experimental plats is shown and the writer includes certain formulae that may be of use to investigators in entomology.

The logic and mathematics of biometry is such a vast subject that, in the time allowed, it is possible to present only a few principles of elementary statistics as illustrated by some of the writer's experiments for the control of the codling moth. These field tests were conducted, during 1920, in Niagara County New York. Incidentally, it might be mentioned that formulae commonly found in texts on statistics have been omitted but those that may be of use to codling moth workers and which are not commonly given have been added for convenience of reference.

Biometry has three divisions: (1) exact measurement of biological phenomena, (2) classification of observations, and (3) refined mathematical analysis of the data. With the exception of noting the use of double dichotomous and manifold classification in the arrangement of the data (Table 1), discussion of the first two divisions will be omitted.

In order that mathematical analysis of experimental data may be precise and the conclusions applicable to a certain region, it is essential that the *universe of investigation* be defined; that the experimental areas be average samples selected from such a universe; and, that each series of plats be uniform, within the limits of normal variation, before any differences of treatment be made. The universe of investigation may be defined as a physiographical region in which the climate and soil is such that the growth habit of bearing orchards are similar for the same variety, and where the seasonal history and habits of the codling moth are fairly constant for the same reason. Owing to the expense involved, the number of field tests is limited, therefore, the experimental areas should be selected with the aim of securing conditions typical of the region. Since the data of experiments on one orchard may never be exactly duplicated in another, each planting may be considered as a random sample in a *universe of experiments*, hence, the importance of repetition of field tests before drawing definite conclusions for an extended area.

Homogeneity of Orchard Plats

That plats upon which different treatments are to be tested may be comparable, it is fundamentally important that, previous to the field

tests, each orchard be uniform, within the limits of normal variation, as regards variety, age, size, habit and yield of trees, soil, cultivation, fertilization, spraying, and—most important of all—that the number of codling moth be the same thruout the planting. Heterogeneity in

TABLE 1. DATA OF CODLING MOTH EXPERIMENT.

				Plat and Tree No.	Infested Apples*					Apples not Infested	Total Apples on Tree
					First Brood			Second Brood	Total Infested		
					Place of Entrance						
					Calyx	Side Deep	Side 'Sting'	Side			
Not Sprayed	No Calyx Treatment			Check 1	34	347	449	0	830	6418	7248
				Check 2	12	571	559	14	1156	6634	7790
				Totals	46	918	1038	14	1986	13052	15038
				Ave.	23	459	504	7	993	6526	75219
Sprayed	Calyx Treatment	No Summer Application		Plat 1 1	2	238	527	6	773	6779	7552
				Plat 1 2	1	229	205	1	436	5871	6307
				Plat 1 3	2	186	260	6	454	3333	3787
				Plat 1 4	2	123	227	0	352	2670	3022
				Totals	7	776	1219	13	2015	18653	20668
				Ave.	1.7	194.0	304.8	3.2	503.8	4663.2	5167
		Summer Application	2½ lbs. Arsenate of Lead per 100 gals. water	Plat 2 1	3	173	535	0	711	9729	10440
				Plat 2 2	0	40	266	3	309	5507	5816
				Plat 2 3	3	139	399	3	544	7564	8108
				Plat 2 4	7	127	630	0	764	7423	8187
				Plat 2 5	5	119	546	0	670	10310	10980
				Plat 2 6	9	284	917	0	1210	7154	8364
				Plat 2 7	0	144	565	5	714	4883	5597
				Plat 2 8	8	192	982	0	1182	8368	9550
				Totals	35	1218	4840	11	6104	60938	67042
				Ave.	4.4	152.2	605.0	1.4	763.0	7617.2	8380.2
			5 lbs. Arsenate of Lead per 100 gals. water	Plat 3 1	1	175	155	0	331	7354	7685
				Plat 3 2	0	129	318	0	447	7674	8121
				Plat 3 3	0	92	258	0	350	7241	7591
				Plat 3 4	2	77	300	0	379	9352	9731
				Plat 3 5	0	79	262	2	343	11328	11671
				Plat 3 6	4	96	482	0	582	8833	9415
				Plat 3 7	1	61	174	1	237	7612	7849
				Totals	8	709	1949	3	2669	59394	62063
				Ave.	1.1	101.3	278.4	0.4	381.3	8484.9	8866.1

*"Worthless" apples include the following infested fruit: "Calyx;" "Side, deep;" and "Second Brood, side."

field plats is one of the causes of excessive variation and a powerful factor in producing uncertainty in the results of a single set of experiments. Generally, conditions of homogeneity are approximated, to a greater or less extent, by the astuteness of the investigator in observing conditions previous to making the experiments. As will be described subsequently, methods of measuring the degree of heterogeneity in field plats have been developed and should be used wherever possible.

Two general methods of compensating for heterogeneity have been in common use and are still to be recommended: (1) duplication and reversal of plats of uniform size in the same orchard, taking a mean of plats treated alike; and (2) the use of a number of plantings in which the tests are repeated, either the same or other seasons.

Determination of Heterogeneity

With varieties that bear annually, one of the safest methods of determining lack of homogeneity would be to select the orchard the year previous to starting the tests and to make counts of infested apples. Having a sufficient number of adjacent trees, the data can be analyzed first for systematic error and then for general heterogenity.

Systematic Error. If the values determined thruout an area tend to increase or decrease from one side to another, or, if certain areas have values considerably higher or lower than others, the material is affected by systematic, error. When this is quite uniform across the orchard, corrections can be computed and applied or plats can be duplicated in a manner to compensate for the differences.

Heterogeneity. The most common lack of uniformity is from tree to tree or between groups of trees. To measure this form of heterogeneity, the methods and formulae of Harris[1] are the best known to the writer Wherever possible there criteria should be applied. The fact that they have been so well described and since the publication is available, further description is unnecessary.

Variation Due to Casual and Undetermined Factors

Variation or individuality is associated with all living matter. This tendency for individuals to vary is responsible for much of the difficulty in the interpretation of the data of field tests, even tho the greatest efforts are made to select homogeneous material and avoide rrors. The

[1]Harris, J. Arthur. Practical Universality of Field Heterogeneity as a Factor Influencing Plat Yields. Jour. Arg. Research 19:.pp 279-314. 1920.

causes of such variation are seldom known, therefore, it is assumed that they occur fortuitously, i. e., they are perfectly random, since they show no regularity or periodicity.

The Measurement of Variation

Averages are used universally and the arithematical mean is the one generally calculated. An average gives no idea of the distribution of the observations, so some measure of the "scatter" of the values is needed. A valuable as well as common measure of variation is the standard deviation which has certain mathematical properties from whch are derived two other measures of variation: the coefficient of variability and the probable error. The standard deviations and coefficients of variability for the several plats shown in Table 1 are given in Table 2.

Table 2. Standard Deviations and Coefficients of Variability of Infestation by Codling Moth in the Plats shown in Table 1.

Plat	Standard Deviation	Coefficient of Variability
	Total Infested Apples	
Check	163.00±77.74	16.41±5.68
1	160.15±44.10	31.45±8.21
2	283.55±51.12	37.16±7.08
3	100.29±19.53	26.30±5.06
	Worthless Apples.	
Check	108.00±51.51	22.09±7.80
1	46.73±12.87	23.48±5.90
2	66.63±12.01	42.17±8.28
3	35.45±6.90	34.46±6.91

Probable Error. Assuming, for the purpose of illustration, that no systematic error affected the plats (Table 1), it is desired to compare the effect of an increased amount of arsenate of lead in the control of the codling moth (Plats 2 and 3). All the plats except the check,, received the same appllication up to the time of the codling moth application, when plat 2 was sprayed with lime-sulphur with 2½ lbs., of dry arsenate of lead in each 100 gallons of material, and Plat 3 received an application of lime-sulphur having 5 lbs., of dry arsenate of lead to each 100 gallons of liquid. Plat 2 has a mean of 158.00 worthless apples[2] and Plat 3 has a mean of 102.86 worthless apples. With no other data to assist in the comparison, it would seem that the additional amount of lead produced

[2]It has seemed desirable to classify the infested apples in two catergories; viz, "Total Infested" and "Worthless". "Total Infested" includes all fruits showing any form of codling moth injury "stings", while not suitable for the New York A Grade, find a readysale under other grades, but apples having deep excavations are usually worthless except for cider stock. "Worthless fruits include the data in Table 1 under the headings "Calyx", "Side, deep", and "Second Brood, Side".

a gain of 55.14 sound apples per tree. If, however, the probable errors of the means be calculated, a measure of comparison is provided. This gives the following data: Plat 2, 158.00 ±16.99; Plat 3, 102.86 ± 9.76; difference, 55.14 ± 19.59. The probable error of a sum or difference of two quantities A ± a and B ± b is given by the formula $E^D = \sqrt{a^2 + b^2}$.

Before the significance of these numbers can be appreciated, it is necessary that some criterion be established as to the relation of a probable error to the number to which it is attached. Without going into a lengthy discussion ,it may be stated that biometricians demand odds of at least 22 to 1 and many require odds of at least 30 to 1 that, should the experiment be repeated, the mean shall fall within certain limits before the result can be called *significant*. Odds of not less than 22 to 1 require that a number shall be at least 3 times its probable error, and odds of not less than 30 to 1 require that a number be not less than 3.17 times its probable error. The writer prefers the latter odds. A simple method of comparison is to take the difference of two means and compute the probable error. The means of the two plats show a difference of 55.14 ± 19.59 and the difference is only 2.81 times its probable error, so is not significant. Stated otherwise, the odds are only about 16 to 1 that, should the experiment be repeated, the mean of Plat 3 would be higher than that of Plat 2, therefore, the data are not conclusive. It should be noted, however, that if total infested fruit is considered, the difference between the two plats is 4.93 times its probable error, so is significant.

The Probable Error of the Mean of a Small Number of Observations

With large numbers of observations, the formula for the calculation of the probable error of a mean is $E_m = \pm .6745 \frac{\sigma}{\sqrt{n}}$ where σ is the standard deviation and n the number of observations. This will be referred to as the Gaussian Formula. If the number of observations (trees in this instance) are less than 16 in any plat, the probable error of the mean computed by the Gaussian formula will be too low, thus giving a higher degree of confidence than the data justify. To overcome this difficulty, some workers, who have been compelled to use few observations, have used modified formulae for the calculation of the probable error of a

mean. Two formulae commonly used are Bessel's and Peter's Approximation Formula. Bessle's Formula is $E_m = \pm .6745 \frac{\sigma}{\sqrt{n-1}}$ and Peter's Approximation Formula is $E .8543 \frac{\Sigma (d)}{n\sqrt{n-1}}$ in which the deviations of the observations from the mean (d) are added, paying no regard to the signs.

In Table 3 is set forth the means of the several plats together with the probable errors of the means calculated by the several formulae. It will be noted that the probable errors computed by the Gaussian formula are generally the lowest, the Bessel formula giving higher values,

TABLE 3. MEANS AND PROBABLE ERRORS CALCULATED BY DIFFERENT METHODS, CODLING MOTH DATA

Plat	Mean	Probable Errors of Mean		
		Gaussian	Bessel	Peters
		Total Infested Apples		
Check	993.00	±77.74	±109.94	±137.79
1	503.75	±54.01	± 62.37	± 65.77
2	763.00	±67.62	± 72.29	± 62.25
3	381.29	±25.56	± 27.62	± 26.23
		Worthless Apples		
Check	489.00	±51.51	± 72.84	± 91.30
1	199.00	±15.76	± 18.20	± 19.40
2	158.00	±15.89	± 16.99	± 15.58
3	102.86	± 9.04	= 9.76	± 9.92

TABLE 4. COMPARISONS OF PLATS USING GAUSIAN, BESSEL AND PETERS PROBABLE ERRORS

Plats compared	Differences	Probable Errors of Difference			Difference divided by		
		Gaussian	Bessel	Peters	Gaussian	Bessel	Peters
		Total Infested Apples					
Check & 1	489.25	±994.41	±126.40	±152.68	5.18	3.87	3.20
Check & 2	230.00	±102.81	±131.58	±154.21	2.24	1.75	1.49
Check & 3	611.71	± 81.55	±113.36	±140.26	7.50	5.40	4.36
1 and 2	259.25	± 86.54	± 95.48	± 95.51	3.00	3.09	3.09
1 and 3	122.46	± 59.75	± 68.21	± 70.81	2.05	1.79	1.73
2 and 3	381.71	± 72.29	± 77.39	± 74.05	5.24	4.93	5.15
		Worthless Apples					
Check & 1	290.00	± 53.87	± 75.08	± 93.34	5.38	3.86	3.11
Check & 2	331.00	± 53.91	± 74.80	± 92.62	6.14	4.43	3.57
Check & 3	386.14	± 52.30	± 73.50	± 91.84	7.38	5.25	4.20
1 and 2	41.00	± 22.38	± 23.68	±24.88	1.83	1.73	1.65
1 and 3	96.14	± 18.17	± 20.65	± 21.79	5.29	4.66	4.41
2 and 3	55.14	± 18.28	± 19.59	± 18.47	3.02	2.81	2.99

while Peters formula gives results sometimes lower than the Gaussian but generally higher than those of the Bessel formula.

Table 4 shows the difference of the means of the several plats together with the probable errors of the differences, using the Gaussian, Bessel and Peters probable errors. It should be noted that a number of plat differences show significance when judged by the Gaussian and Bessel errors, altho five differences in each series lack odds of 30 to 1. When compared by means of Peter's probable errors, seven differences are not significant. Of the Bessel and Peters formulae, the writer prefers the former (i. e., when the number of observations is less than 16) because it shows greater consistancy. However, the data should be tested by both formulae and, if a difference tested by either formula shows odds of less than 30 to 1, the results should be accepted with caution. The results shown in Table 4 point to the conclusion that, while the experiment is indicative that increased amounts of arsenate of lead give better control of the codling moth, it lacks much of proving the point.

The Probable Error of a Standard Deviation of a Small Number of Observations

Since the probable error of a standard deviation may be calculated from the probable error of the mean of the same observations by dividing the latter by $\sqrt{2}$, it follows that a simple method of computing the probable error of the standard deviation, when the number of observations is 15 or less, is to calculate the probable error of the mean by either Bessel or Peter's formula and divide this number by $\sqrt{2}$. The values of the probable errors of the standard deviations given in Table 2 were secured in this manner, using the formula of Bessel.

The Influence of Numbers on the Confidence That Can be Placed in the Data of an Experiment

To give an idea of the number of trees per plat required to secure chances of 30 to 1 in this experiment, a few additional calculations have been added. Assuming that the means and standard deviations of all the plats remained the same but that 16 trees were used in each plat, would the results have been significant? With 16 trees per plat the Gaussian formula would be reasonably safe. The results are set forth in Table 5. It will be noted that, with one exception, the twelve comparisons show significant differences. These figures strongly indicate that, in the writers experiments, at least 16 trees should have been used

before it would have been possible to definitely conclude that, *for that season*, larger amounts of arsenate of lead gave better control.

TABLE 5. MEANS AND PROBABLE ERRORS COMPUTED ON THE BASIS OF SIXTEEN TREES PER PLAT

Plat	Mean	Plats Compared	Difference	Difference divided by probable error
		Total Infested Apples		
Check	993.00±27.49	Check & 1	489.25±38.53	12.70
1	503.75±27.00	Check & 2	230.00±55.15	4.17
2	763.00±47.81	Check & 3	611.71±32.27	18.96
3	381.29±16.91	1 and 2	259.25±54.91	4.72
		1 and 3	122.46±31.86	3.84
		2 and 3	381.71±50.71	7.53
		Worthless Apples		
Check	489.00±18.21	Check & 1	290.00±19.84	14.62
1	199.00± 7.88	Check & 2	331.00±21.40	15.47
2	158.00±11.24	Check & 3	386.14±19.17	20.14
3	102.86± 5.98	1 and 2	41.00±13.73	2.99
		1 and 3	96.14± 9.89	9.72
		2 and 3	55.14±12.73	4.33

Since a single set of field tests constitutes one observation in a universe of experiments, it is obvious that recommendations to the farming public should not be made until the tests have been repeated during the same and different seasons. Not less than ten such trials should be made and 16 would be better before making changes in the spray schedule. To increase the amount of poison in sprays means an additional cost of thousands of dollars to fruit growers, therefore, it behooves the experimenter to have abundant data that has been carefully analyzed and found significant before changes should be advocated.

USEFUL PROBABLE ERROR FORMULAE FOR ENTOMOLOGISTS

The economic entomologist will have occasion to use several formulae for probable errors which are not generally found in texts on statistical methods. These have been included for convenience.

If a general mean is desired of several quantities affected with the errors e_1, e_2, etc., the formula is $E_{gm} = \pm\frac{\sqrt{e_1^2 + e_2^2 + \ldots e_n^2}}{n}$

in which n is the number of values used in computing the general mean.

The probable error of the *product* of two quantities, $A \pm a$ and $B \pm b$ is $E_p = \pm \sqrt{(Ab)^2 + (Ba)^2}$.

The probable error of the *quotient*, $\frac{B \pm b}{A \pm a}$ is

$$E_q = \pm \frac{\sqrt{\left(\frac{Ba}{A}\right)^2 + b^2}}{A}$$

Should the results be desired in the form of a percentage, $100 \frac{B \pm b}{A \pm a}$ the probable error is

$$E_R = \pm 100 \frac{\sqrt{\left(\frac{Ba}{A}\right)^2 + b^2}}{A}$$

ESTIMATING THE ABUNDANCE AND DAMAGE BY THE SAN JOSE SCALE

By JOHN J. DAVIS, *Purdue University, Lafayette, Indiana*

SUMMARY

The gradual increase of the San Jose scale, *Aspidiotus perniciosus* Comst., is less likely to be recognized before it becomes a serious factor than many insects which appear suddenly or which cause immediately visible injury, nor is the relative importance of the loss of trees in comparison with an annual crop usually realized. The various types and degrees of injury must be taken into consideration in estimating abundance and damage, which may include a weakening or killing of the tree, spotting of fruit so as to make it unmarketable, and subjection of the trees to further insect and disease troubles following the weakening effect of scale. Other factors entering into the problem are the vigor and resistance of individual trees and individual varieties to scale injury. The degree of infestation and method of making counts are reported. To reach a basis for estimating monetary losses figures are given which enables the author to estimate the crop loss to an acre of apples, if allowed to become badly infested, to be $1,008.00 and this even if the scale is eventually controlled and the trees brought back into a thrifty condition.

Injury by a scale insect is less conspicuous than that by chinch bugs, army worms, and similar insects which appear suddenly, usually without advance warning. The San Jose Scale, for example, gradually saps the life of the tree and often the orchardist does not recognize its harmfulness or the impending danger until the branches are dying, although sometimes the infestation may be recognized earlier by a spotting of the fruit. Neither does the orchardist always realize the after-effect following even practical eradication of the insect. The farmer may immediate-

ly recognize the loss of an animal or the destruction of a clover crop by grasshoppers, or an onion crop by thrips but he is less likely to recognize gradual injury to orchard trees or realize the relative importance of the loss of trees which required careful attention for 15 or 20 years.

We find, on analyzing the problem, that the San Jose scale is an important factor in profitable orcharding from several angles.

FIRST, the moderate infestation may weaken the trees.

SECOND, the moderate infestation, if not checked, soon becomes a serious one, resulting in the killing of individual branches and usually the entire tree.

THIRD, the moderate or severe infestation may be completely eradicated and still there remains an after-effect which may last for a number of years, preventing the maturing of a satisfactory or profitable crop.

FOURTH, the light, moderate, or severe infestation may cause a spotting of the fruit, resulting in a depreciation in value, often reducing the crop below the point of profit.

FIFTH, trees weakened by the San Jose Scale are subject to many additional troubles. For example, on apple, bitter rot often follows scale infestation in southern Indiana and farther south; on peach, the shot hole borer has an excellent opportunity to gain a foothold, in fact, it may infest and kill the trees in a single season.

Other factors must be kept in mind. Thus we find the more vigorous trees are more subject to injury, probably because scale increases more rapidly. Likewise certain varieties are more subject to heavy infestation than others, thus, in Indiana, vigorous Grimes trees have been killed in one year, when the dormant spray was omitted. Similarly, the length of time that encrusted trees will recover after being cleaned up depends on varieties.

To determine the monetary losses from different degrees and kinds of infestation, a questionnaire was sent to 25 orchardists in Indiana, and of the 18 replies received, the following averages were figured.

The average yield of a twenty-year old apple tree is 12 bushels and the average value of the tree is $40.00. The depreciation in value of the crop, as a result of scale spotting varies from 15 to 100 per cent, averaging 50 per cent. A tree weakened sufficiently to make production unprofitable requires two to five years to bring it back into profitable bearing, after the scale has been controlled, Figures submitted by orchardists show the cost of one dormant spray to be 15 to 60 cents per tree, the lowest estimate for lubricating oil emulsion, the intermediate costs for lime-sulphur, and the highest expense for the more expensive

miscible oils. The average value of fruit for well-cared for orchards is $1.00 per bushel, which will give us an average value of the crop for a twenty year old tree as $12.00. Thus we might figure the annual loss where scales are sufficiently abundant to badly spot fruit as about $252.00 per acre. The weakened effect, before and after control, may result in an average of four years unproductiveness, amounting to a monetary crop loss of $1,008.00 per acre. These figures should be sufficient to suggest a basis for estimating monetary losses from the San Jose scale under varying conditions and degrees of injury.

We recognize the injury and financial loss that may result from San Jose scale but it is more difficult to estimate the abundance and degree of infestation. As a matter of fact, the degree of infestation is less significant inasmuch as other factors, such as location, vigor of tree and varieties enter into the problem in a material way. This is not true of course in estimating the value of insecticide treatments and the ideas which we are going to express have a more direct bearing on that feature of our work.

No exact rules can be given for determining abundance. Estimations are only approximate and the relative value of figures or degrees of infestation will vary with the individual making the records.

Methods of determining the value of insecticide treatments by relative abundance of the scale offer a means of estimating the abundance of an insect. These methods which were used as a whole or in part, for determining the value of insecticide treatment, by W. P. Flint in Illinois, J. J. Culver in several states and the writer in Indiana are, briefly, as follows:

Previous to treatments the infestation is estimated. The degrees are specified as *very slight* where only an occasional scale could be found, *slight* where scales were not common but could be located without difficulty, *moderate* where scales were fairly common and nearing an encrusted condition, *heavy* where the scale was doing noticeable injury and where occassional limbs were encrusted, and *heavy encrusted* where many branches were encrusted. In other words the degree of infestation was gauged from one to ten, a number one infestation being very slight and ten the heavy encrusted condition. At the same time this infestation was estimated, 500 scales from at least a half dozen twigs from different parts of the tree or trees, were examined under a binocular microscope to determine the percentage of dead and live scales. In making counts on apple it was found desirable to use one and two-year wood.

A month after the treatment counts were again made of dead and live scale from both treated and check trees.

After the first brood of young had settled, counts were made to determine the number of newly settled scales on a given length of at least ten representative twigs of new wood from each tree or from an equal number of leaves.

At harvest, the fruit, in the case of apple, was examined and graded on the basis of scale infestation, using the terms very slight, slight, moderate, heavy, and heavy encrusted, or using an arbitrary scale running from one to ten to determine the degree of infestation.

In the fall after the majority of leaves were off, the trees were examined to determine the degree of infestation, applying the method used previous to the treatment, for comparison with the original degree of infestation.

Inasmuch as the personal element is certain to enter into counts and estimations, all counts and estimations used in a comparsion should be made by the same person, and it is often desirable to have separate sets of counts made by another individual to check upon.

METHODS OF ESTIMATING BOLL WEEVIL LOSSES

By W. D. HUNTER, *Bureau of Entomology*

ABSTRACT

Probably more attempts have been made to estimate boll weevil, ***Anthonomus grandis*** Boh., losses accurately than have been made in the case of any other insect. Such estimates have been made by entomologists, crop reporters and commercial organizations. By far the most accurate estimates have been found to be those made by entomologists. A very accurate estimate can be made by comparing production on plots treated with calcium arsenate and on plots untreated. The difference in production is a precise measure of the amount of damage caused by the weevil. The usefulness of this method could be greatly increased by test plats provided by state entomologists in different parts of their states. Estimates made by crop reporters have been found to show a strong trend toward exaggeration. Those made by commercial organizations are frequently colored by market conditions.

The American cotton crop has probably incited more statistical inquiry than any other crop produced in this country. It is not surprising that a great deal of the available statistical talent has directed its energies towards estimating the damage done by the boll weevil.

In general the methods of estimating boll weevil losses may be thrown into three groups, namely, those followed by entomologists, those by crop reporters and those by commercial organizations.

The methods followed by entomologists may be discussed in two

classes, one dealing with regional losses in a series of years and the other with losses accruing in a single district in a single season.

In determining regional losses the only method followed has been to compare the production per acre before and after the advent of the weevil. This is by no means a precise method. One reason is that there are frequently trends towards reduction in production due to the depletion of the soil and to other factors, which began to appear long before the coming of the weevil. It is frequently impossible to differentiate between the effect of these trends and what the weevil has done. Another difficulty is that production per acre in the country is not determined accurately except in the census years and intermediate years are only estimated.

In determining the loss in any one season an effort has been made by entomologists to ascertain the amount by finding the percentage of infested squares and bolls throughout the season. This quantity can be obtained readily. With its use and a proper allowance for natural shedding a fairly accurate basis is secured. The practical difficulty is to obtain sufficiently extensive series of field examinations. Up to recent times this has been the most accurate method available. Now, however, a different system can be followed and is being used to a considerable extent. This makes use of the fact that when properly applied calcium arsenate practically eliminates the factor of weevil damage in a field. The difference, therefore, between the production on treated plots and on check areas gives an accurate reading of the results of the work of the weevil. The degree of accuracy attained depends upon the proper selection of control areas (not always an easy matter) and the attacks of such insects as plant lice, which, however, generally affect controls and treated areas to about the same extent. The Bureau of Entomology has had numerous experimental plantings for several years in many states. They were located with reference to regional differences. The results obtained give by far the most accurate effort of estimating damage which has ever been devised. The precision and usefulness of this system could be greatly increased by the cooperation of the states in placing treated and check plots wherever needed.

The method of estimating insect losses through the Crop Reporting Service is well known. Trained correspondents of several classes report their opinions as to the amount of weevil injury based on their own observations and information obtained from local farmers. The result is merely a crystallization of the conception of the farmers as to what the losses may have been. Its greatest weakness is in the natural

tendency to attribute to one conspicuous factor like the boll weevil the damage actually attributable to a number of causes. The trend in these estimates is undoubtedly towards exaggeration, as has been shown by many comparisons between Crop Reporting Service estimates and those made by entomologists which have been made by students in the Department of Agriculture.

The Department is now conducting a large experiment in increasing the accuracy of crop correspondents estimates of weevil losses. Experts of the Bureau of Entomology and Plant Industry have drawn up a questionnaire which has been sent to about 150,000 farmers throughout the South. This questionnaire will make it possible to correlate reductions in the crop with many factors entering into its production, including varieties, time of planting, spacing and many others. It will also furnish a basis for correlating different methods of weevil control and production. According to the statisticians it will yield the largest number of variables which have ever been considered in any statistical inquiry. The work of tabulating and correlating on special machines will occupy the time of several men for a number of months. The outcome of this inquiry can not be foretold, but it probably will yield very favorable results.

The commercial estimates of weevil losses in many cases are made through the reports of local correspondents. In many cases the number of correspondents is small and it is suspected that some of the estimates are merely evolved in offices in New York, New Orleans or other places. While many of the estimates are made with care and good intent, there is always the possibility that any commercial report may be colored by the bull or bear interest of the concern which makes it.

ESTIMATING THE ABUNDANCE OF, AND DAMAGE DONE BY GRASSHOPPERS

By STEWART LOCKWOOD, *In charge Billings Laboratory, Bureau of Entomology*

ABSTRACT

Because of extreme activity the numbers of grasshoppers, Acrididae, are hard to estimate. By aid of a field glass the observer can stand at some distance and count those in a given unit. Many units of ground should be so counted in a field before an estimate of the grasshoppers can be made.

A knowledge of the egg laying habits is necessary before an estimate of the number of eggs in a locality can be made.

Estimating the per cent of damage in a particular field is done by comparison of the amount of damaged seed in several small units with the undamaged seed.

When making up a statement of the damage done by grasshoppers over a wide area, the entomologist should, when possible, compare the yield of damaged sections with the yield of localities where there were no grasshoppers but which had other limiting factors equal. A comparison of the yield during the grasshopper infestation with the yield in the same localities but in years when there were few, if any, grasshoppers can be made but before the entomologist can estimate the damage done by grasshoppers, he must know the action, during the years under comparison, of other limiting factors such as rainfall, temperature, sunshine, winds, and crop diseases.

Estimating the numbers of an insect which during the daylight is almost continually on the move and that becomes disturbed at the first unusual movement of the observer is sometimes an exasperating proposition. In 1920 C. L. Corkins, investigating *Melanoplus atlanis* (Riley), by aeroplane in North Dakota, found the bulk of a swarm flying between five and 600 feet and observed a few stragglers at an altitude of 1,650 feet above ground.

In our work with grasshoppers we often have to estimate the number of eggs in a locality and, later, do the same with both nymphs and adults.

In investigating the number of eggs with the thought of prediction of the character of damage in the future, a knowledge of the egg-laying habits of the economic species common to the particular section is, of course, necessary. A wide variance in the choice of place for oviposition occurs with different species in the hard spring wheat area, and to a lesser degree this choice differs with the same species in different localities. The prevailing methods of tillage function importantly in this matter. In the Northern Great Plains, *Melanoplus bivittatus* (Say), *Melanoplus differentialis* (Thomas), *Camnula pellucida* (Scudder), and *Dissosteira carolina* (Linnaeus) commonly deposit their eggs in beds having rather distinct borders. The eggs of *Melanoplus atlanis* (Riley) are not as commonly placed in beds but more often are scattered over wider areas. Consequently, when making estimates of the possibility of outbreaks of the first four species previously mentioned, the number and size of the egg beds is taken into consideration but with *Melanoplus atlanis* (Riley), the number of pods located is the determining factor. In a section where the ground is rocky yet covered with grass or other vegetation, the eggs of *Melanoplus bivittatus* (Say) commonly are found at the base of half-buried rocks, as a rule more numerously on the side that receives the direct sunlight between noon and four o'clock in the afternoon. In some sections the eggs of this species occur in the crowns of alfalfa but in the alfalfa regions of western Nebraska and eastern Wyoming, these eggs are more often found close to the roots of grass

that is growing in the alfalfa. This also applies to *Melanoplus differentialis* (Thomas). Fence rows, ditch banks, closed drains, and roadsides having a southern exposure and stack yards are also places where these two species commonly oviposit. In the irrigated alfalfa fields of Wyoming, *Camnula pellucida* (Scudder) chooses high, dry knolls as the best places for its eggs. Further north this species prefers to deposit its eggs directly into the roots of grass. In the hard spring wheat section, the small grains grown on rather light sandy soil often are more severely damaged by *Melanoplus atlanis* (Riley) in the early part of the year than nearby crops grown in heavier ground. In such sandy sections the eggs of this species are commonly found at the bases of old grain stubble. The strips of sod between the fields and between the roadsides and fields and headlands are the places where *atlansis* eggs can be expected. We have had better success in locating these eggs under mats of dead vegetation, such as a pile of Russian thistles or tumbling mustard lodged against a fence, than in places where there was no such covering. In the open prairie this species of grasshopper is inclined to deposit its eggs on sandy or rocky knolls or ridges having more or less growing vegetation. The number of egg parasites and predators in these localities is also a factor to be reckoned with.

In estimating the number of grasshoppers in a field, several methods may be used. Where the grasshoppers are dense and moving in one direction an imaginary line may be drawn across the path of movement and measured in feet, yards or rods, and after sufficient time has elapsed for them to have gone forward across the line a foot, a yard or a rod, the number having crossed this line within the measured unit can be considered as those contained in a square foot, yard or rod. This process should be repeated in several places as well as measurements made of the occupied area before an accurate estimate of the numbers of grasshoppers in such a band can be made. It has been our experience in the Northern Great Plains that the nymphs of *Camnula pellucida* (Scudder) assume the marching habit far oftener than the other economic species. We have not found such marching bands of grasshoppers very often.

When making a quick examination of a field where no experiment is to be carried on but where an estimate of the relative number of grasshoppers, in comparison with other fields, is needed the worker soon learns to make fairly accurate comparisons by walking thru fields and making observations as he goes. This often is done by men in charge of county or township campaigns or by their scouts and tends to de-

termine the amount of materials which the grower will need to poison the grasshoppers.

Attempts have been made to estimate the number of grasshoppers by collectors who used nets of the same size and made a certain number of sweepings in a given number of steps but we have discarded this method because it was felt that a compilation of the reports of several workers using this method was not accurate enough for scientific purposes. Sweepings made at different times of the day, under varying climatic conditions, in different crops, together with the varying speed of the operators upset the uniformity of such reports.

While not essential it is highly desirous that sufficient plots of crop be used in carrying out a control experiment that have equal or nearly equal degrees of infestation. When the grasshoppers are adult the person about to engage in such an experiment may approach his plots in the early morning as soon as it is light enough to see distinctly and before the grasshoppers move readily. By observing caution the grasshoppers that are resting inside of a given unit, say a square yard, can be counted. Naturally, counts in such plots must be made in several places. The locations where counts are made may be chosen in much the same manner as that adopted by an adjuster in determining the amount of hail damage to a crop. When the grasshoppers are still quite small, such a method does not give as accurate a count as when larger. Young grasshoppers are inclined to shelter themselves under close-growing foliage and in cracks and rubbish during the nights and colder parts of the first daylight hours. Under such conditions the number of grasshoppers in a predetermined unit can be counted with the aid of a low-powered field glass, by slowly approaching near the places chosen at random and remaining there quiet long enough to permit the few grasshoppers that have fled to be replaced. It is easier to do this during the extreme heat of the day when they are sluggish. At this time the grasshoppers are resting in the foliage, on the tops of clods of earth and in spots bare of vegetation. This method may also be used with adults.

While the damage that grasshoppers do to individual plants is plainly discernible, the amount of damage to a crop is not always readily estimated. It sometimes happens that in the spring of the year small grain is ravaged by young grasshoppers coming in from adjacent egg beds. They eat as fast as they travel leaving borders of bare soil. If these are killed before more damage is done, the percentage of damage can readily be calculated. It is not often that a second growth comes from

the roots left in the ground but this occasionally occurs. Where the grasshoppers are uniformly numerous in a growing field the damage they do is not so easily seen unless it be of a high percentage. Well-developed growing grain may be severely checked, yet mature a very good crop later on if the grasshoppers are killed. The yield of hay taken from an infested field when compared with the production during years when there were no grasshoppers, other factors being equal, presents a definite idea of the damage done to forage crops. In the case of either cereal or field crops, grown for seed, and which are nearing maturity before grasshoppers occur in the field, the percentage of damage done may be estimated by examining different parts of the field and by counting the chewed kernels, dropped heads or seed balls in a predetermined unit and comparing this count with the seed in undamaged areas. This is the method that adjusters commonly use to ascertain the damage to a crop by hail.

In making up a statement of grasshopper damage for a state or even a county, the aid of several people is needed unless the entomologist has spent the entire time in a district where the estimate is made, and, even then, a close knowledge of past crop values is needed. We cannot conceive that the observations of a single person could be sufficiently accurate for him to properly estimate the damage done by grasshoppers in an entire state; at least, in a state so large as those in the northern plains. When working with such a problem, we ask and receive aid from other agricultural workers. County agricultural agents furnish information as to the acreage infested and the intensity of the infestation. Such information often is furnished, plotted on county maps and shaded to represent the degree of infestation. They also submit their own estimates of damage done. This is compared with information obtained from other sources.

Limiting factors other than grasshoppers must be taken into consideration. From plant pathologists and agronomists the general condition of the crop and the prevalence of plant diseases is obtained. From the reports of climatological observers we obtain the departure from normal of precipitation, temperature, wind, and number of days of sunshine. From the reports of crop statisticians the production of the crops the grasshoppers have damaged is obtained and this is compared with the normal production and the production during years when grasshoppers were not prevalent. When possible the production in damaged sections is compared with that of adjacent districts having other factors equal. A compilation of reports received from those whose crops have

been damaged is not in itself an accurate estimate but we believe such reports have sufficient merit to warrant their being requested, especially where the entomologist has a large list of active farmer cooperators. A questionnaire should be furnished which can be filled out in short concise statements.

Having in hand a knowledge of the infested areas, the degree of infestation, the production of such areas during immune periods, and the production during infestation and the action of other limiting factors, we believe that the entomologist may compile a statement which, after comparison with the individual estimates of county agents and farmer cooperators, will be a close estimate of the damage done. We believe that such an estimate should present the damage done in terms of percentage of crop loss rather than monetary loss.

THE APPLICATION OF STATISTICAL METHODS TO THE DETERMINATION OF ABUNDANCE OF AND DAMAGE BY HESSIAN FLY[1]

By W. H. LARRIMER, *Entomologist, U. S. Bureau of Entomology, West Lafayette, Indiana*

ABSTRACT

The discussion of the determination of abundance of Hessian fly, *Phytophaga destructor* Say, is confined to methods used at the U. S. Entomological Field Station at West Lafayette, Indiana. Percentage and intensity of infestation are determined in the fall as an indication of the magnitude of the menace to fall sown wheat and the success of the advised control measures. A similar determination is made in the late spring to indicate the probable status of the Hessian fly menace to wheat sown the following fall.

As yet no methods have been found acceptable for the determination either before or after harvest of the amount of damage done by Hessian fly.

The use of so-called statistics in studies of this nature as well as in other entomological investigations without appropriate consideration of the theory of probability is questioned.

Most of the pioneer entomologists of this country must have felt the need of figures for the basis of opinions and consequently devised some sort of statistical methods for use in connection with their study of Hessian fly. Practically every economic entomologist since has contrived or adopted some scheme of measuring or estimating abundance of and damage by this most important insect pest of wheat. It is intended to confine the present discussion of methods of determination of abundance to those now used in making such determinations at the

[1] *Phytophaga destructor* Say: family Cecidomyidae: order Diptera.

U. S. Entomological Field Station at West Lafayette, Indiana and to express an opinion as to the general unreliability of methods of determination of amount of damage.

Abundance

The abundance of Hesssian fly is determined twice each year, once in the fall and again late in the spring, each time for a different purpose. Both determinations are made by the same method and at the time when most of the fly forms of the respective generations are in the flaxseed stage.

Regular date of sowing experiments distributed over the area under observation but entirely at random as far as Hessian fly infestation is concerned, serve as the source of material. These experiments consist of five to seven sowings of approximately one-tenth acre each, made at intervals of three to five days before and after a date previously considered as the best sowing date. A sample of wheat plants is taken from each sowing by a method which is an adjustment of the various theoretical and practical demands. In this case it consists of approximately one hundred plants taken in five random lots of approximately twenty plants or culms each. The samples thus obtained are removed to the laboratory where they are carefully examined and the following information is recorded; number and respective date of sowings; number of plants and number of culms examined; percent of plants and percent of culms infested; for the fly forms that are larvae, the size, total number and maximum and average number per infested culm; and for the fly forms that are puparia, the total number and the maximum and average number per infested culm.

Flaxseeds obtained from the fall examination are caged in 9x36mm. glass vials plugged with cotton and inserted in holes bored in plaster slabs to rear possible parasites for specific determination. No attempt is made to determine the percentage of parasitism in the fall because the presence or absence of parasites at this time does not directly affect any possible artifical control measures as yet developed and does not assist in the formulation of a program of action to meet a possible spring menace of Hessian fly.

The principal results therefore of the fall examination are the determination for each experiment of the percentage and intensity of infestation of the samples from the sowings made on different dates and the determination and distribution of the parasites obtained. The

percentage and intensity of infestation are used as an indication of the success or failure of the advised seeding dates and of the magnitude of the menace that existed to fall sown wheat.

Though only a matter of opinion, the advised seeding dates are considered good when the maximum infestation in any sample taken from sowings on or after these dates is less than ten percent of the infestation of any sample taken from sowings made before these advised dates. Intensity is the term used to represent the average number of fly forms per infested culm or plant.

Flaxseeds from the late spring examination are disposed of in the same manner as those obtained in the fall except that fifty, to one hundred are dissected to determine the percentage of parasitism.

The principal results of the late spring examination are the determination for each experiment of the percentage and intensity of infestation of the samples taken from all the sowings and the percentage of parasitism, determination and distribution of parasites of the flaxseeds thus obtained. This information is then used to indicate the probable status of the Hessian fly menace to fall sown wheat and thus is the basis for an opinion as to how much emphasis should be given to secure the observance of advised dates of seeding and other control measures the following fall. In addition to the information previously discussed the figures obtained serve as an indication of variations in the abundance of Hessian fly in different localities for the same year and in the same locality from year to year.

Damage

Considerable thought has been given to the possibility of devising some scheme of correlation of fall and spring infestation of Hessian fly with the amount of resultant damage as indicated by final yield. It seems quite obvious that damage and sometimes severe loss can be directly associated with either fall or spring infestation. In the case of abandonment of entire fields which sometimes occurs due to extremely heavy and timely infestation, no index of injury is needed to predict the extent of reduction in yield at harvest time. Some damage must be caused by less severe but varying degrees of infestation but because of inconstant variation of other contributing factors, no satisfactory scheme has yet been developed by which the effect on final yield may be predicted with even a fair degree of dependability by a known percentage of infestation in fall or spring.

Some effort has also been made to develop a method to be used after harvest to estimate with some fair degree of reliability the total amount of damage that can be charged up to Hessian fly. For instance, the estimated number of acres of wheat sown in the state of Indiana in the fall of 1919 was 1,960,000. . Of this amount 225,000 acres were estimated to have been abandoned in the spring of 1920 because of infestation by Hessian fly the previous fall. From the acreage left standing, the yield was estimated at 7,280,000 bushels less than would have been produced by a ten year average yield. Considering this deficiency due to Hessian fly and computing the probable yield of the abandoned acreage on the basis of the ten year average yield, a total loss of 11,260,000 bushels could be estimated.

As a contrast to this scheme of estimation there is the well authenticated case of a similar estimate being made in a mid-western state where the task was assigned to a farm director and two agronomists. Each of the three made up his mind off hand and independently. The average thus obtained was considered too large and after considerable discussion it was cut exactly in half. This final result actually appears in the publications of that state as an unqualified statement of a definite amount of damage caused by Hessian fly.

This second case need not be further considered except to express the opinion that such estimates are far too frequently made. Without going into details in discussing the first case, the many non-compensating and irregular factors other than Hessian fly infestation that enter into the final yield of wheat should be considered. The effect of variation of soil and seasonal conditions is exceedingly important. Joint worm is some years worse in early and other years worse in late sown wheat. The greater wheat stem maggot is evaded by delayed sowing much the same as Hessian fly. Leaf rust is usually worse in the fall on early sown wheat and in spring on the later sowings, but this factor is far from constant from year to year. The observance of advised seeding dates varies in different parts of the country and in the same section from year to year. All of these interrelated factors, together with many more which could be mentioned, certainly emphasize the extent of the unreliability of any such estimates of the amount of damage by Hessian fly. Have not such estimates in the past been largely figures based originally on an opinion rather than an opinion based on figures? It might be pertinent to inquire as to the fundamental purpose which it is intended that such estimates should serve and whether or not this

purpose might not be defeated or perhaps served just as well if the nature of their dependability was recognized, admitted and furnished along with the figures.

This brings up an old subject about which many books have been written and in which renewed interest has been taken in various fields of research within the last few years. It is desired to call attention to the disregard, especially by Entomologists, of the Theory of Probability, which in all available texts examined has been treated as indispensable to the application of Statistical Methods.

Theory of Probability

While, as has been stated, the earliest workers on Hessian fly employed some sort of Statistical Methods in estimating its abundance and damage, there does not seem to be a single reference of an attempt to apply the Theory of Probability to determine the reliability of such methods. As a matter of history, the Theory of Probability is older than that of Statistics, and has now been developed to the place where its application lends a powerful tool to investigations in many lines of research. By the application of one of the principles of this theory the measure of unreliability of the determination of any value is given by the probable error of the determination. This is usually expressed in the form of a pair of values, one above and the other below the value determined, the chances being even that the true value lies between these limits.

By the application of the Theory of Probability to methods of determination of the abundance of and damage by Hessian fly, it seems quite likely that data from which heretofore definite conclusions have been drawn really should have been taken merely as indications more or less reliable as the particular case may have justified. Often percentages of infestation and parasitism have been recorded without giving the probable error or any description of the method of determination. All too frequently such percentages are expressed in fractions, sometimes even hundredths of one percent, entirely disregarding any error of method which doubtless exists to the extent of several percent. Such practices are often not only the basis of unfounded conclusions, conflicting recommendations and hair splitting estimates, but are in themselves misleading in that they assume a non-existent refinement of method.

Would it be presumptuous to suggest that much real progress could be accomplished by the careful consideration of the application of the Theory of Probability not only to future work along lines as herein discussed, but to many other entomological problems as well.

MR. C. L. MARLATT: The symposium which we have listened to has been one of much interest and profit. The different speakers in the discussion of methods and their values as seemed to them pertinent have covered the field so well that there is little left to be said on the subject assigned to me. I think if we properly digest what has been said this morning it will be possible for any of us to choose and follow a method or methods which will meet our needs and if we do so we will come pretty near achieving as good statistical work on insect damage as is now possible. Any phase of the subject that I might now take up would be more or less in repetition of what has already been said by one or more of the speakers. A few general considerations may nevertheless be opportune.

The discussions have ranged from the practical or more commonplace field methods of estimate to strictly technical and intensive methods and both systems undoubtedly have their place. The very commendable tendency of the modern to increased technical accuracy should not, however, lead us to lose sight of the value of the older and simpler methods of estimating insect losses. I am willing to wager that an expert who has been working for several years on the San Jose scale or codling moth subjects, for example—and I say an expert as contrasted with someone inexperienced—can make, after a fairly thorough survey of the orchard concerned, a general estimate that will be about right as to infestation and damage and that sort of estimating undoubtedly will continue to be the one generally followed.

I am inclined to believe the personal element has more to do with the accuracy of results than the method. If you run over in your minds the estimates which have been made and published in past years. I think it is clear that such personal element has been the dominating factor and this idea has been brought out by many of the speakers.

In the matter of all such estimates as we are now considering it is well to remember that the world has become very doubtful of or at least has come to look with some question on statistics and statisticians, and we in the Federal Department of Agriculture do not have to go very far

afield to find that out. Perhaps no office in the Department has been in hot water so often, rightly or wrongly, as our statistical office. We, as insect-loss statisticians, may get too close a view of our subject and lose the necessary contacts or perspectives. It is important to remember that we are not alone in the field of estimating plant pest damage. There are the phytopathologists, nematologists, ornithologists, and mammalogists, to say nothing of the ecologists and other ologists, and all of these must have their rake -off! In our estimates we must take account of all these factors and leave a little over for the other fellows, and a little over after all that for the farmer! He must have something!

In general in our estimates of crop damage the crop produced is the last word on the subject. If such crop of wheat, for example, is only 5 bushels to the acre under severe Hessian fly attack—other conditions being about normal—one can fairly safely charge the reduction from a normal of say 15 bushels to the acre to the fly. The crop itself, in other words, tells the story. That all the factors concerned in possible crop production must be taken into account has been stressed by most of the speakers, but I think none of them has indicated that the farmer has some rights in the matter, and that you must leave something for him. I can illustrate by the story of a young lawyer who had won his first case and had secured quite a large sum for his client. He was disturbed about what fee to charge and went to an old seasoned lawyer and asked him if he thought 10 per cent would be about right. The answer was: "I think I would leave your client a little more than 10% if I were you."

On the subject of the detail necessary in estimating losses I think there is some tendency to go into too much minutiae. Such course may lead, as already indicated, to a narrowing of the viewpoint and a failure to properly gage the general damage for the region or district concerned. A great deal of insect damage is spotted and there is a human tendency which it is almost impossible to overcome and regulate—to go to the spot where the damage is worst. This danger adheres in the selection of the field, orchard or tree to be the basis of the estimate and this is one of the difficulties which we have all got to face and keep in mind. One may easily go to the extreme of detail of observation, countings and tabulations, involving weeks and months of hard work and accumulate altogether too much of statistics and then naturally you want to publish it and that is the worst of it! I believe in accuracy but please file most of the working details and tables in your offices. If anyone questions your

conclusions, these details will be available to substantiate your work. Do not insist on their being published. I am one of the editors of a research magazine—that of the Department of Agriculture—and I know what comes over my desk and the burden of detail often gives me great pain.

In conclusion, and referring again to the widespread doubt and suspicion which attaches to statistics and statisticians, I will venture another old story, namely, the definition of liars: "Liars, damn liars, and statisticians."

MR. H. A. GOSSARD: I noted in my memorandum, as the speakers were going along, some of the things Dr. Marlatt brought out, and I am glad he brought those things out so distinctly. I will not now need to say very much about them, but he is the last speaker on the floor, and, of course, he is leaving the last impression. I hardly agree with him to the full degree of his seeming condemnation or perhaps I would better say the limitations he is disposed to endorse; but I heartily agree with him about the personal element that so vitally affects all conclusions and forecasts. I recognize in this method of taking statistics one of the methods by which we may hope to make progress. It is worth trying. Don't trust it too far, but it is one of the most promising programs we have for making real progress.

I thoroughly agree with Dr. Marlatt that there is very much in the personal element, and while I won't say there is such a thing as an instinctive Entomologist, who knows and acts by instinct, there is sometimes something that is quite akin to it. Yet, I usually find that the man who is operating apparently by instinct, really has in the back of his head somewhere, some statistical data, or some experience which is the basis for his judgment. Now, for instance, when we come to the matter of entomological forecasting—we have done considerable forecasting at one time or another in our state in regard to the coming of Hessian flies; we add something to the method that Mr. Larrimer has presented—in fact, we have all of his data placed at our disposal. But we have added to that for the past several years, a wheat survey made just before the harvest time, by which we take samples from several fields in each county and make an accurate count of the degree of infestation. But we don't wholly trust that count. We don't pretend that the figures we get are absolutely accurate or representative, but we know they are approximately accurate, within 10 or 15 per cent. anyway, if the infestation is high, and much closer if the infestation is low. We know

beyond guessing that if there is a wide outbreak of Hessian flies impending, we will be able to discove r it, and it will not take us by surprise.

Then, having determined this fact, we further proceed to gather enough data—trustworthy data—so that we can say just when the people in our state should sow; we determine this by another plan. We check several methods against each other. We prepare an emergence cage in which the adult flies can come forth, trying to make the conditions in the cage as nearly like those outside as possible. We keep a daily record of the number of flies appearing in the cage. We also have a certain number of marked wheat plants on which we keep the record of the number of eggs that are laid each day, and we scrape those eggs off after each examination so as to leave a new, clean slate to receive the eggs for the next day. We keep the records throughout the egg-laying period, so we have the date of maximum egg-laying. We have checking against these two devices, some wire screens set up at right angles to each other to catch the wind from all four directions equally well, and the wires coated with Tanglefoot; and we take the number of flies that are caught daily in that.

We find these devices check against each other splendidly. There is only a difference of a few hours we get as the date of maximum general emergence as determined by these three checks against each other, and in that way we determine to a considerable extent—in fact, we depend quite largely on this combination method to say when the time for our wheat growers to sow has come.

But we do not trust this conclusion absolutely. Suppose we were to find from the emergence records, that we were getting several days beyond the time which average and long experience, and such records as Mr. Larrimer has accumulated, would show to be best. That is one of the things that has been right in the back of our heads, as something we might be obliged to consider any year. If we were to find the maximum emergence crawling up to a very, very late date, the question would come up whether we could wait any longer; it might be two or three days before we would have the maximum record, but just upon the general principle that we would be apt to run into more danger from winter killing than from Hessian fly, we would probably give the signal to sow in such a case. We have not as yet been compelled to do that, but it has been in our minds a number of times that we might be obliged to choose this course.

I recall one or two instances of estimating Hessian fly damage that seemed very accurate to us at the time we made the calculations, and yet

I wouldn't trust the estimates today at all. I think, if any of you remember our old Hessian Fly Bulletin, No. 177, you will probably recall the picture of two jars in which we showed a number of grains of wheat threshed out from a certain number of straws, and in another jar was the yield from an equal number of straws which were not infested with Hessian flies. We assumed that the difference between those two measures indicated the loss.

I don't think so at all today, because I have learned that the Hessian fly in the spring of the year seeks plants of a certain stage of development and size, and that they seek those plants which are backward and weak, and I am satisfied that the difference as shown between those pictured yields is altogether too great. In other words, the figures "lie." So such things are not always altogether reliable.

Another point was brought out which I also wish to emphasize. We should be very careful to distinguish between actual loss and monetary loss. The damage is usually stated in terms of the consumer's dollar. As a matter of fact, the producer would take an entirely different view of the subject, and his monetary loss is entirely different. In many cases Hessian fly damage is of tremendous importance and a great loss to our population as a whole and to the consuming public, yet it may have been an actual advantage to the farmer and producer because the insect limited their surplus and prevented a depression of prices.

When I read that in Ohio, in the year 1900, there was a monetary damage of $15,000,000 I don't know what the damage was in bushels, unless I know the average price of wheat for that year. If it had been stated in bushels in the first place, I wouldn't be obliged to go back and find out what the price was.

And the same thing is true throughout. I am heartily in sympathy with the plans of Mr. Hyslop. I believe there is a future for forecasting. I am wondering whether or not a little more determined cooperation on the part of the collaborators would not materially aid the pest survey. These collaborators are very busy. We have our own problems in our own states, and we can't add on several additional projects, but the survey is a matter of such promise and of such great importance that it would seem to me we might take on, each of us, some one particular problem if that were assigned to us, and we would then see what we could do with it as part of the plan that Mr. Hyslop has proposed.

MR. J. A. HYSLOP: I certainly wish to thank Professor Gossard for

his suggestion of help from our collaborators. I may propose this to several of them. I believe, however, in this symposium, the main feature brought out has been the fact that we *do need a unit standard* in *measuring insect* abundance, not necessarily to be applied to highly mathematical statistical tests, but if we have some standard unit and one man reports, we will know what he means.

I had two most amusing reports coming respectively from a northern and a southern state in 1921. The northern state, one of the lake states, reported that the corn earworm was devastating the corn crop. The southern report stated that the corn earworm was moderately abundant. I happened to know the conditions in the two states, so I sent the same letter to each of the two reporters and asked them how many ears in a dozen were badly infested, and how much of the corn was eaten from each ear. The report of the northrn state came back that there were one or two ears in a dozen that were worm-eaten at the tip. From the southern state the reply came back: "about every ear and about half the corn on each ear."

We really need some measuring stick by which a man can publish information about an insect, and another man can use that information in comparing the results obtained, particularly in insecticide work.

MR. E. P. FELT: Wouldn't it be possible to have as an outcome of this symposium, a committee to attempt to standardize in a general way, methods of estimating. We cannot compel an individual to use a certain standard, but if a committee could formulate the most approved methods for the calculation of injury in relation to different insects under various conditions, and bring a little pressure for the adoption of a standard, not necessarily too complex, but simple and basic, I believe it would be a long step forward in solving a rather vexatious problem such as the insect survey has to meet now.

I would move that the Chair appoint such a committee. (It was so voted).

MR. R. L. WEBSTER: It seems to me that if we are going to make estimates of crop damage from insects, it is necessary that we determine what is a full crop. In some of the data published by the Department of Agriculture the best crop that has been produced in a locality, such as in one county, for instance is considered as a full crop.

It seems to me this is wrong. I cannot imagine conditions that are so favorable that there is no loss by any reason whatever, either from insects or other factors, in any particular area. I think we should con-

sider as a full crop, a figure considerably higher than the highest known crop in any one locality.

MR. W. P. FLINT: Regarding the figures Mr. Webster gave yesterday—it so happens that the man in charge of gathering the agricultural statistics in Illinois is quite interested in insects, and he, at my suggestion, sent out a number of questions to the 1500 crop reporters in the State regarding the damage caused by insects. Last year he sent out a question on chinch-bug damage. While there were some cases of over-estimating and under-estimating in individual counties, the average of these reports gave an 8% loss of the corn crop of the State which was caused by chinch-bug in 1922, and which so far as we can tell was not very far wrong.

I wonder if, in some of the other states, it would not be possible to get these questions included so that Entomologists could get some data from the crop reporters.

MR. W. E. HINDS: Mr. Chairman, I think there is something we entomologists can do in the way of educating statisticians, and getting them to take care of some of these inquiries in a more definite way than they have been accustomed to do in the past.

A number of years ago in Alabama we made decided progress by getting the statisticians to gather data on the yield of lint cotton per acre for each county through the State. That has helped us decidedly, and has given us a means of gauging boll weevil damage from year to year in a degree that wouldn't be possible otherwise.

MR. L. O. HOWARD: Whatever we decide about the damage done by insects and the amount that is saved through our labors, people will hardly believe us. Let me illustrate. A good many years ago Congress, in order to make committee places for all of its members, established a series of committees on expenditures in the different departments of the government—one for the Treasury Department, another for the Interior Department, and so on, including one for the Department of Agriculture. For years little or nothing was done by most of these committees; but an energetic new man was finally appointed chairman of the committee on expenditures in the Department of Agriculture, and he asked the Secretary, "How much is your Department saving the government?" The Secretary passed the question on to the bureau chiefs. I asked Doctor Marlatt, Doctor Quaintance and the other chiefs of sections in the Bureau of Entomology to give me their estimates as to the saving in their particular branches. When I

received their replies they totaled an almost unbelievable sum; so I cut it in half and sent it to the Secretary of Agriculture. The amount was so much larger than that sent in by any other Bureau that the Secretary in turn cut my sum in half. When the report went to the chairman of the committee, he cut in half the amount submitted by the Secretary for the Bureau of Entomology. So the amount finally printed was one-eighth of the original estimate. However, since that date such great work has been done that I am sure that the original estimate that came to me from branch chiefs is by far nearer the truth than the figure published.

PRESIDENT A. G. RUGGLES: The next paper is by E. R. Sasscer and C. A. Weigel.

RECENT DEVELOPMENTS IN GREENHOUSE FUMIGATION WITH HYDROCYANIC-ACID GAS

By E. R. SASSCER, *Collaborator*, and C. A. WEIGEL, *Entomologist, Greenhouse Insects Investigations, Bureau of Entomology, Washington, D. C.*

ABSTRACT

A simple device adapted for simultaneously dropping cyanide into generators was developed and proved practical in commercial greenhouses, Liquid hydrocyanic acid (equivalent to ¾ ounce NaCN per 1,000 cubic feet) was effective against several species of aphids, white fly, and scale insects, but it can not yet be safely recommended for use by the average florist. Further data on plant tolerance of Kentia and Areca palms for HCN fumigation is presented. At low temperature, 1 ounce NaCN per 1,000 cubic feet was not effective against the eggs of *Pseudaonidia duplex* (Ckll.). Miscellaneous data on insect control with HCN is given. Preliminary notes on the use and effectiveness of calcium cyanide indicate that it may become useful as a greenhouse fumigant.

While experimenting with liquid hydrocyanic acid to determine its value for greenhouse fumigation a slight modification of the device employed for liberating the liquid was found to be useful and applicable for fumigating with the pot method as well. The very rapid volatilization of liquid hyrdocyanic acid due to the high temperatures that normally prevail in greenhouses necessitated the development of some method of insuring safe liberation and uniform distribution of the gas. After some preliminary experimentation it was found that the "applicator" as used in California was not so well adapted to greenhouse purposes. The length of the commercial type of houses would necessitate the operator stopping at several points in the house in the application of the liquid and would thus expose him directly to the

poisonous gas. To avoid this risk the following equipment was devised.

Small bottles were spaced equidistant from each other and fastened by means of a small wooden plate to a revolving shaft made of one-half inch gas piping. Pipe extensions of a "T" at one end of the shaft served as a handle for turning over all the bottles at one time. The total amount of liquid hydrocyanic acid required for a given charge was divided among a definite number of bottles which were kept corked. When the gas was to be released the stoppers were removed in succession beginning at the far end and moving toward the door. The bottles were then upset simultaneously by giving the shaft a half turn. The evaporation surface under each bottle was greatly increased by spreading newspapers in a cone-shaped manner over an inverted 10 inch flower pot.

In utilizing the pot method of generating the gas the bottles were omitted and in lieu of these, cups 3 inches high made of ordinary metal spouting were attached to the wooden blocks on the shaft (Fig. 4). After pouring the water and acid into the generators, one of which is placed below each cup, the fumigator distributes the packages of sodium cyanide in the cups and by a turn of the handle the chemical is dumped simultaneously into each generator. In this manner he is not exposed to the gas as may sometimes be the case when the packages are dropped individually into the water and acid.

After trying out this method several times successfully in a small greenhouse the device was installed in a long, single range type approximately 225 feet in length. This improvement worked so satisfactorily that it was deemed desirable to bring it to the attention of entomologists since it overcomes the necessity of being in the house as the chemicals are mixed. Moreover, this feature will undoubtedly stimulate more interest among florists when they become familiar with it in the use of this gas. The fact that one man can safely fumigate a house or possibly a series of open range houses by this method should influence its adoption.

In this connection it seems desirable to refer to Figures 5 and 6 which illustrate a convenient arrangement which recently has been devised for opening the ventilators from the outside of the greenhouse.

Experiments With Liquid Hydrocyanic Acid

During the spring of 1923 investigations involving the use of liquid hydrocyanic acid were undertaken and very detailed and thorough box experiments were first conducted which were later followed by green-

TABLE I. SHOWING RESULTS OF BOX FUMIGATION WITH LIQUID HYDROCYANIC ACID AT RATES EQUIVALENT TO FROM ¾ TO 2½ OUNCES OF SODIUM CYANID PER 1,000 CUBIC FEET OF SPACE WITH AN EXPOSURE OF ONE HOUR

Dosage NaCN in Ounces	°F.	Humidity %	Host	Insect	Interval in days	Condition after fumigation dead	Condition after fumigation alive	Control %
¾	69.8	72	Adiantum	Idiopterus sp.	1	285	0	100
do	do	do	Geranium	Illinoia pelargonii	1	240	0	100
do	do	do	Chrysanthemum*	Macrosiphoniella sanborni	1	1055	2	99.8
do	do	do	Marguerite	Myzus persicae	1	170	1	99.4
do	do	do	Rose	Myzaphis sp.	1	315	0	100
do	do	do	Geranium	Trialeurodes vaporariorum	1	85	0	100
do	do	do	Croton	Pseudococcus citri	3	5	56	8.1
do	do	do	Azalea	Eriococcus azaleae	11	50	51	49.5
do	do	do	Cattleya sp.	Chrysomphalus biformis	10	780	1	99.8
do	do	do	Croton	Coccus elongatus	15	1322	35	97.4
do	84	73	Jerusalem cherry*	Myzus persicae	1	285	5	98.2
do	do	do	Lantana	Orthezia insignis	1	233	0	100
do	do	do	Rose*	Thrips tabaci	1	220	1	99.5
1	69.8	72	Adiantum*	Idiopterus sp.	1	145	0	100
do	do	do	Gernaium	Illinoia pelargonii	1	85	0	100
do	do	do	Marguerite*	Myzus persicae	1	115	4	96.6
do	do	do	Rose*	Myzaphis sp.	3	280	0	100
do	do	do	Geranium	Trialeurodes vaporariorum	1	50	0	100
do	do	do	Croton	Pseudococcus citri	3	2	27	6.9
do	do	do	Azalea	Eriococcus azaleae	11	26	11	70.2
do	do	do	Cattleya sp.	Chrysomphalus biformis	10	1210	0	100
do	do	do	Croton	Coccus elongatus	17	1670	391	81.
do	80.6	64	Lantana	Orthezia insignis	1	430	0	100
do	do	do	Nephrolepsis sp.	Hemichionaspis aspidistrae	7	36	3	92.3
1½	68	67	Kentia sp.	Chrysomphalus aonidum	10	67	0	100
do	do	do	Kentia sp.	Chrysomphalus dictyospermi	10	45	0	100
do	do	do	Nephrolepsis sp.*	Pseudococcus citri	1	1	49	2
2½	78.8	57	Aspidistra	Chrysomphalus aonidum	10	295	2	99.3

*Burning.

house tests to determine what strength of gas a wide range of plants would tolerate.

These tests, the results of which are presented in Table I, were con-

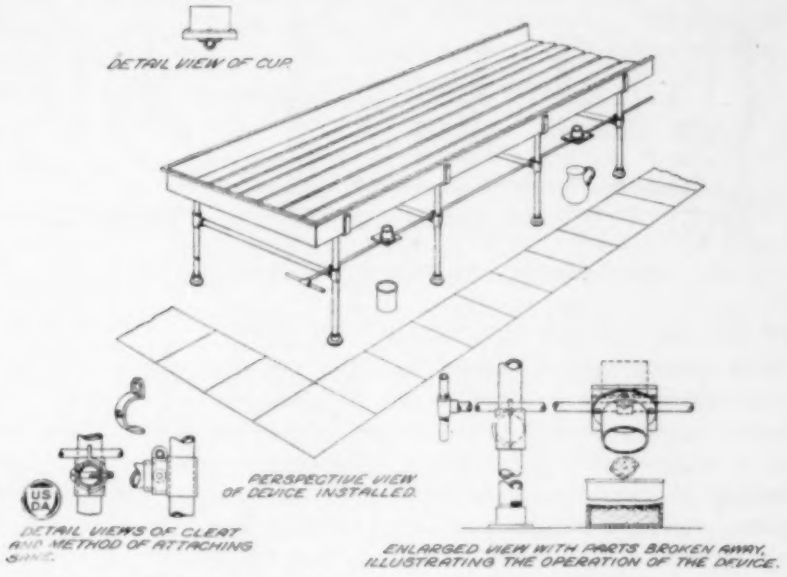

DETAIL VIEW OF CUP.
PERSPECTIVE VIEW OF DEVICE INSTALLED.
DETAIL VIEWS OF CLEAT AND METHOD OF ATTACHING SAME.
ENLARGED VIEW WITH PARTS BROKEN AWAY, ILLUSTRATING THE OPERATION OF THE DEVICE.

Fig. 4.—Device for dropping cyanide into generators simultaneously.

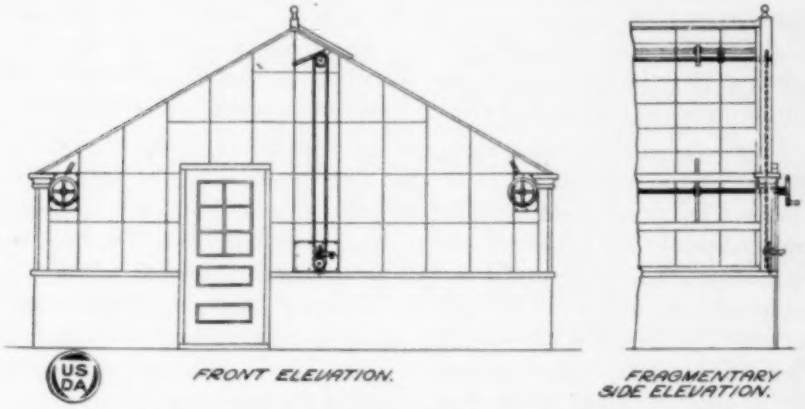


Fig. 5.—Device for opening ventilators from outside.

ducted during April, May and June 1923, in a 200 cubic foot fumigating box. Twenty cubic centimeters of the liquid hydrocyanic acid testing

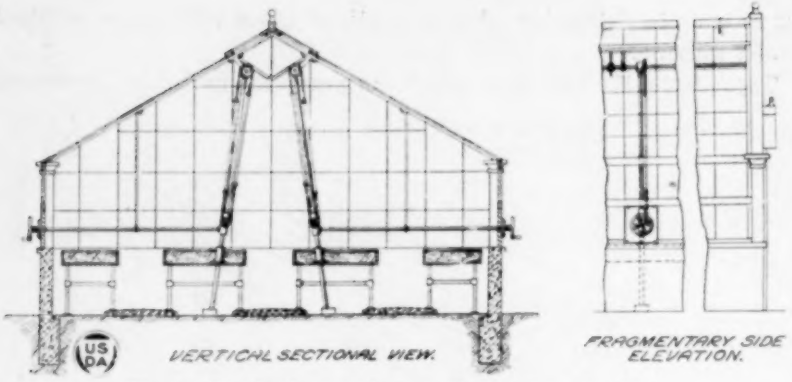


Fig. 6.—Device for opening ventilators from outside.

over 95% purity were used as the equivalent of 1 ounce sodium cyanide[1].

It is obvious from the above table that the equivalent of ¾ ounce sodium cyanide per 1,000 cubic feet of space (or 15cc of liquid) was effective against the following common greenhouse insects, *Idiopterus* sp., *Illinoia pelargonii*, *Myzaphis* sp., *Macrosiphoniella sanborni*, *Myzus persicae*, *Trialeurodes vaporariorum*, *Orthezia insignis*, *Chrysomphalus biformis*, *Coccus elongatus*, and *Thrips tabaci*, killing from 97 to 100 per cent of them. This dosage, however, was not effective against the immature stages of white fly, *Trialeurodes vaporariorum*, or the adults and eggs of the azalea bark scale, *Eriococcus azaleae*, and mealybugs, *Pseudococcus citri*, or the eggs of the long soft scale, *Coccus elongatus*. Slight tip burning occurred only on chrysanthemums, rose, and Jerusalem cherry. These results also demonstrate that liquid hydrocyanic acid is equally as effective as the pot method of generating the gas.

Upon carrying the experiments to the greenhouse it was necessary to determine the distribution of the gas and its effect on the hosts. The plants in the experiment were divided into three lots, with one lot at each end and one in the middle of the house. One plant of each variety was represented in each lot and arranged in the same order so that if burning occurred it would be in evidence on the same variety of plants in each lot and this would serve as an index of equal distribution of the gas. Burning occurred on one variety of jasminum in each lot of plants indicating that comparative equal diffusion had taken place.

It is evident from the experiments thus far conducted that while this

[1]Woglum, R. S., "Fumigation of Citrus Trees for Control of Insect Pests," Farmers' Bulletin 1321, p. 26, 1923.

gas may have an efficiency equivalent to the gas produced by the pot method, the manner of application has not reached the stage where it could be safely recommended to the average florist. The advisability of conducting this gas into a greenhouse by means of a force pump and then liberating it under pressure through a system of perforated pipes with adjustable nozzles permanently installed near the ridge of a house is now being made the subject of a special investigation.

Plant Tolerance Experiments With Kentia and Areca Palms

The regulations of the Louisiana State Department of Agriculture prescribe that nursery stock and plants originating within the camphor scale infested area and which are offered for sale interstate or intrastate must be hand inspected and fumigated with hydrocyanic-acid gas under supervision prior to shipment. In connection with this work the State inspectors frequently noted that Kentia palms in particular were severely burned when exposed to the gas at the ¾ ounce dosage sodium cyanide per 1,000 cubic feet of space. It seemed necessary, therefore, to conduct tests to determine the reason for the burning. The results of these experiments which were conducted at New Orleans by the junior author and W. D. Whitcomb during January and February 1923, demonstrated the following:

All experiments show that *Kentia belmoreana* are burned to some degree if exposed for 1 hour to hydrocyanic-acid gas with a concentration of ¾ ounce sodium cyanide, or greater, per 1,000 cubic feet of space with humidity ranging from 56 to 86 per cent.

Exposure to sunlight both *before* and *after* treatment tends to intensify the burning but the results were not all uniform. Fronds exposed *directly* to the light before and after were more severely burned.

Wetting the plants prior to fumigation did not materially influence the results.

No burning was observed on new spikes. There was no apparent difference in the tolerance of old and new fronds.

Experiments with *Areca lutescens* indicate a much greater resistance to hydrocyanic-acid gas. However, some burning occurred under such unfavorable conditions as a humidity of 75 to 80 per cent and exposure to strong sunlight after treatment.

It is evident from the results thus far obtained that Kentia palms cannot be fumigated with hydrocyanic-acid gas, even as low as ¾

ounce, without severe injury unless the plants are protected from sunlight for a period greater than 48 hours after treatment.

Incidentally it might be well to mention the fact that during the above tests the 1 and 2 ounce dosages per 1,000 cubic feet were repeated in order to verify the results of the previous season on the effectiveness of these dosages against the eggs of *Pseudaonidia duplex* at temperatures ranging from 46° F., and higher. Since crawlers hatched at the 1 ounce strength it indicated that it is not effective during low temperatures.

Miscellaneous Results with Hydrocyanic-Acid Gas

Additional data has been accumula ed at intermittent periods during the year on the efficiency of this gas, some of the outstanding results of which are as follows: The 2½ ounce rate killed 100 per cent of the soft brown scale, *Coccus hesperidum* (L), and the chaff scale, *Parlatoria pergandii* Comst., but was only partially effective in controlling larvae of the azalea leaf roller or miner, *Gracilaria azaleella*, and the azalea bark scale *Eriococcus azaleae* Comst. Results of plant tolerance experiments indicated that poinsettias when the bracts had developed their intensity of red color can stand as high as 1½ ounces, and that azaleas ma be fumigated as high as the 5 ounce per 1,000 cubic feet rate although it caused tip burning of one variety.

Calcium Cyanide as a Greenhouse Fumigant

During the past summer samples of calcium cyanide in granular and dust form were received from Dr. Wm. Moore and experiments were undertaken to determine their value as greenhouse fumigants. Preliminary experiments in a 200 cubic foot box with the dust were made and more recently similar tests were conducted under actual greenhouse conditions. In the box tests the calcium cyanide dust was spread over damp newspapers in amounts equivalent to from one-half to one ounce of sodium cyanide per 1,000 cubic feet and the plants were exposed for one hour to the gas evolved. Two species of aphids were used viz: *Macrosiphoniella sanborni* on chrysanthemums in experiments 1 to 9, and *Illinoia pelargonii* on geraniums in experiment 10. Vinca, Jerusalem cherry, Martha Washington geranium, begonia, and Kentia palms were also included and escaped injury. The ¾ ounce rate caused slight tip burning on Lantana and snapdragon, and the 1 ounce rate on chr santhemums. These results are shown in Table II.

TABLE II. SHOWING CONTROL OBTAINED WITH CALCIUM CYANIDE IN BOX FUMIGATION EXPERIMENTS

Exp. No.	Dosage NaCN in Ounces	Temperature °F	Humidity %	Interval in days	Condition after fumigation: dead	Condition after fumigation: alive	Control %
1	¼	71.6	85	1	79	94	45.6
2	do	69.2	90	½	370	7	98.1
3	¾	69.4	90	1	185	2	98.9
4	do	71.6	90	1	111	50	68.9
5	do	72.5	69	1	368	15	96.
6	1	74.3	67	½	280	0	100.
7	do	68.9	91	1	118	15	88.7
8	do	80.6	64	1	165	2	98.8
9	do	82.4	65	1	925	30	96.7
10	do	80.6	64	1	830	0	100.

In the ½ ounce equivalent dosage accurate records of mortality could not be made the same day because some individuals revived after being brought into fresh air. The aphids were only stupefied by fumigation at the ¾ ounce rate when exposures lasted 15, 30, and 45 minutes respectively, and most of them soon recovered.

After these tests were completed it was learned that spreading the dust directly on the moist newspapers caused complex reactions which may have reduced the amount of hydrocyanic-acid gas actually released.

Plant tolerance tests of the dust were then made under greenhouse conditions. For this purpose 8 varieties of plants known to be very sensitive to hydrocyanic-acid gas were selected. Ten plants of each variety were fumigated at rates equivalent to ½, ¾ and 1 ounce of sodium cyanide per 1,000 cubic feet for one hour. The temperature and

TABLE III. SHOWING TOLERANCE OF DIFFERENT VARIETIES OF PLANTS WHEN FUMIGATED UNDER GREENHOUSE CONDITIONS WITH CALCIUM CYANIDE

Host	Degree of burning at dosages equivalent to sodium cyanide in ounces: ½	¾	1
Ageratum	Slight	None	Severe
Coleus	None	None	None
Artemisia	None	None	Slight
Heliotrope	Very slight	Very slight	Severe
Jasminum grandiflorum	Tip very slight	Tip slight	Tip severe
Lantana elegantissima	None	None	None
Ipomoea grandiflora	None	None	Slight
Salvia	None	Slight	Severe

humidity conditions for these experiments were as follows: 73° F., and 84%; 72°F., and 75%; and 68 F., and 83%.

The dust was applied in the units to be fumigated by means of a small hand duster to insure equal distribution. Since hydrocyanic-acid gas is given off when the particles of calcium cyanide dust are exposed to moist air it was assumed that by forcibly blowing the material into a greenhouse a nearly complete reaction should take place resulting in a maximum liberation of gas. Encouraged by the slight degree of injury indicated in Table III, a larger house of approximately 18,000 cubic feet of space involving many varieties of bedding and ornamental plants was fumigated in the manner just described, and with similar results.

From the evidence of plant tolerance thus far obtained with very susceptible plants it seems likely that this material can be adapted for greenhouse fumigation purposes. However, considerable investigation remains to be done before its status as a greenhouse fumigant can be definitely assured. These investigations involve (1) perfecting methods of application, (2) determining the rate of evolution of gas under varying atmospheric conditions, and (3) ascertaining its insecticidal efficiency.

PRESIDENT A. G. RUGGLES: The next paper, will be read by C. C. Compton.

THE USE OF LUBRICATING OIL EMULSION ON GREENHOUSE SCALE INSECTS

By C. C. COMPTON, *Natural History Survey, Urbana, Ill.*

ABSTRACT

Lubricating oil emulsion spray at 1% strength has proven very effective in controlling scale insects, Coccidae, under greenhouse conditions. No injury to palms has resulted from the spray at this strength with the exception of one case of very slight injury when the application was made on a very cloudy day. On bright, sunny days a spray at 2% strength has been used without injury but is not recommended.

There is a distinct demand for an insecticide for use in combating scale insects on greenhouse plants. Since scale insects are most troublesome on foliage plants, grown largely for the attractiveness of their leaves, it is important to have an insecticide that will not injure the foliage and yet be effective against the scale. The work with this emulsion was carried on by the writer in the Chicago district during 1922 and 1923.

The lubricating oil emulsion spray at 1% strength has proven itself 90–100% efficient in controlling scale insects on palms and rubber plants without injury to the foliage. In large amounts the stock emulsion is used at the rate of 1½ gallons to 100 gallons of water. For smaller amounts 2 ounces to 1 gallon of water is satisfactory.

PREPARATION OF "BOILED" LUBRICATING OIL EMULSION FORMULA FOR STOCK EMULSION

Oil—(Sp. Gr. 0.886—viscosity 365.3—Volatility 4.9%	1 gallon
Water	¼ gallon
*Potash fish-oil soap	2 pounds

The water, soap and oil are placed in a kettle or other receptacle and heated to a boil. Boil for about five minutes being careful not to burn the mixture, remove from the fire or turn off the steam and pump twice at a pressure of 50 to 150 pounds. Make sure that all the mixture passes thru the pump twice. Do not allow the mixture to cool before pumping.

A barrel pump has been found adequate for preparing the emulsion in sufficient quantities for greenhouse work.

Precaution should be taken to prevent the stock emulsion from freezing.

The following are the most troublesome and destructive of the scale insects with which we have to deal in greenhouses in this district, they are given in the order of their importance.

Palms and *Ficus* sp.

(1) The Circular or Florida Red Scale, *Chysomphalus aonidum* Linn., commonly found on *Kentia* sp., *K. forsteriana*, *K. belmoreana*, *Phoenix* sp., *Latania borbonica* and *Ficus* sp.

(2) The Oleander Scale, *Aspidiotus hederae* Vall. Commonly found on *Kentia* sp., *Phoenix* sp., and the areca palm, *Areca verschaffeltii*.

(3) The Tessellated Palm Scale, *Lecanium tessellatum* Sign., found principally on *Kentia* sp. and the areca palm, *Areca verschaffeltii*.

Ferns.

(1) The Fern Scale, *Hemichionaspis aspidistrae* Sign., which is most destructive on the Boston fern.

*The amount of soap depends on the hardness of the water. In this work I have used 2 pounds in every case.

Control Experiments

Table No. 1.

Plant	Scale infesting plants	House Day	House Night	Result of examination after 48 hours No. Live scale	Result of examination after 48 hours No. Dead scale	Percent killed	Injury to plants
(1) Kentia sp.	Fl. Red Scale, Oleander Scale	70	60	27	268	90	None
(2) Kentia sp.	F. R. Scale, Ol. Scale	70	60	0	240	100	None
(3) Phoenix sp.	F. R. Scale	70	60	7	304	98	None
(4) Kentia sp.	F. R. Scale	70	60	6	294	98	None
(5) Ficus sp.	F. R. Scale	70	60	0	70	100	None
(6) Latania borbonica	F R. Scale	70	60	0	242	100	None
(7) Boston Fern	Fern Scale	70	65	0	40	100	Severe

Remarks: In every case the emulsion was used at 1% strength and was applied in the morning. Six inch sections of leaves were marked off with paper clips. The spray was applied with a compressed air sprayer. Forty eight hours after the spray was applied counts of the dead and live scale were made as above. In every case the application was made on a bright, sunny day.

Table No. 2.

Plant	Scale infesting plants	House Day	House Night	Result of examination after 48 hours No. Live scale	Result of examination after 48 hours No. Dead scale	Percent killed	Injury to plants
(1) Kentia sp.	F. R. Scale, Tessellated P. Scale	65	60	8	192	96	Very slight
(2) Areca sp.	Tessellated P. Scale	70	60	5	120	96	None
(3) Phoenix sp.	F. R. Scale, Ol. Scale	70	60	0	122	100	None
(4) Ficus sp.	F. R. Scale	65	60	0	110	100	None

Remarks: Emulsions used at 1% strength and applied in morning. Sections of leaves marked off as in Table No. 1 and counts made in the same manner. The spray was applied with a barrel pump. Spraying was done on bright, sunny days with the exception of (1) when the spray was applied on a very dark day.

As the tables above will show this spray has given excellent control

of scale insects on palms and Ficus sp. One case of very slight injury to the newly formed leaves of *Kentia belmoreana* was observed. Table No. 2 (1). The house temperature at this time was 65 degrees and the spray was applied on a very dark day followed by several cloudy days. On bright, sunny days the emulsion has been used at 2% strength on Kentia sp. without injury to the foliage but is not recommended since the 1% strength is sufficient to give 95–100% control with one application. Besides killing the live scale on the plants this spray loosens the dead scale and old scale covering eggs so that syringing under pressure at the time of watering will rid the plants of both. The spray also spreads and sticks very well and will remain on the plants several weeks. For this reason young scale are prevented from becoming established, particularly *Lecanium tessellatum* Sign., which is viviparous. Leaves of plants sprayed are given a clear and healthy color and dirt or dust that collects on the plants is more readily washed off the sprayed plants than is the case with the unsprayed plants.

The lubricating oil emulsion spray is equally effective in controlling the Fern Scale, *Hemichionaspis aspidistrae* Sign., but is not recommended because of the liability of injury to the foliage of the plants. See table No. 1 (7).

PRESIDENT A. G. RUGGLES: A paper will now be presented by Mr. J. R. Watson.

CONTROL OF ROOT-KNOT NEMATODES ON FLORIDA TRUCK FARMS

By J. R. WATSON

ABSTRACT

Starvation. Culture of an immune cover crop during the summer with constant cultivation to keep down weeds and prevent encysting.

Soil Fumigation. Use of a combined treatment of sodiun cyanide and ammonium sulphate; Calcium cyanamid; calcium cyanide; sulphur.

Heat as a control measure.

Flooding as a control measure.

Incidental control of insects in the soil.

Perhaps some of the members may feel that a paper on nematodes is a bit out of place in a meeting of entomologists, but in our southern states, at least, some one must tackle the problem, and generally the choice lies between the entomologist and the plant pathologist, and a nematode is certainly more closely related to an insect than to a fungus.

Furthermore, the work of soil fumigation admits of wide application to injurious insects as well.

In our work in Florida we have approached the subject largely from the view point of the gardener and trucker. For the general farmer, and even for the farmer who combines considerable trucking with his staple crops, the cheapest and most desirable method of dealing with this pest is doubtless the time-honored one of rotation of crops, growing for two or three years on the infested land crops more or less resistant to the nematodes, such as corn, grains, Brabham, Iron, or Victory cowpeas, velvet beans, etc. But the time involved is a serious objection to one practicing more intensive trucking. He cannot afford to devote his high-priced land to the above mentioned crops with their relatively low return per acre, and most truck crops are seriously affected by the root-knot organism. To meet the needs of the trucker an endeavor has been made to find a quicker method of controlling the pest. However, even for the intensive trucker, rotation of crops should not be abandoned. We have accumulated considerable evidence that there are among the nematodes strains which have become adapted to certain crops. We have repeatedly observed that when a crop of lettuce, for instance, heavily infested with root-knot, is harvested from the land, the land can at once be set out to celery with comparatively little damage, whereas a second crop of lettuce on the land is seriously affected. These observations are in direct contradiction to those obtained by Bessey on this subject and will need careful verification by pot experiments before we can consider the question settled.

In all our work commercial control rather than complete eradication has been our aim. Florida soils, unless newly cleared, are so universally infested with nematodes that even if we should completely eradicate the pest from a piece of ground it would be very quickly reinfested from surrounding plots, as is newly cleared land. Our aim, therefore, has been rather to reduce the nematodes to such an extent that the farmer is able to grow a susceptible crop on the land during the next trucking season. This is much less expensive than would be complete eradication.

Our work has been largely along two lines, starvation and soil fumigation.

Starvation

The Florida trucking industry has a favoring circumstance in the fight against nematodes in that it is limited to the fall, winter, and spring months, leaving the land unoccupied during the summer, the most active season for nematodes. Formerly it was almost universal to

abandon the fields after the last truck crop was harvested to grass and weeds. Among these would be enough hosts of the nematodes to carry the infestation thru the summer. Furthermore, the heavy rains of the summer compact the soil to the exclusion of the optimum amount of air, as shown by the general acid reaction of such ground. These conditions tend to keep the nematodes in the encysted state so that they are carried over until trucking operations are begun again in the fall.

One of our earliest attempts to control nematodes in infested land was by means of the summer fallow, the idea being to keep the soil constantly stirred and aerated so that the eggs would be forced to hatch, and at the same time to keep the land barren of all vegetation, in order to starve out the nematodes. The land was accordingly plowed and harrowed at itervals of ten days and after every heavy rain that packed the soil. A crust was never allowed to remain on the land. This kept the soil well aerated, and this in connection with the abundant moisture and high temperature of the summer season forced the eggs to hatch. As far as nematode control is concerned this procedure has worked out very well, but as was to be expected the effect on soil fertility is very deleterious. The hot sun on the bare ground and the heavy rains cause the loss of a large part of the plant food and are very injurious to soil organisms. However, the method is still occasionally used by a number of truckers who regard their farms only as a site for growing crops, expecting to buy their soil from the fertilizer salesman.

In an endeavor to avoid the injurious effects of the summer fallow we modified it by growing on the land some practically immune plant but maintained the constant cultivation and freedom from weeds, the idea being to shade the ground and thus prevent the injurious effects on the soil fertility; at the same time preserving the beneficial effects of constant cultivation. For a cover crop we turned to velvet beans for two reasons. In the first place they are practically immune to root-knot, being much more resistant than Brabham, or any other variety of cowpeas, and in the second place they make a rank growth during the summer time and completely shade the ground. It is to be observed that this method differs from the old method of crop rotation in that the land is kept under constant cultivation and a crust is never allowed to remain on the soil; also in the more careful elimination of weeds and grass. To secure this result, one or two hoeings when the velvet beans are young are necessary, and very frequently a hand weeding in the row as well. The results have been very satisfactory. Generally we have secured as thoro a control of nematodes in one summer from

June or July to October as we secured by the older and more careless method of crop rotation in two or three years. In every case where the method has been carefully applied it has reduced the nematodes to a point where it was possible to profitably grow highly susceptible plants such as okra thruout the succeeding trucking season.

Soil Fumigation

Seed beds present another problem calling for more complete eradication of nematodes, particularly in the case of crops like celery or lettuce, which are planted in the summer when nematodes are most active. On the other hand, the limited area and the high value of the crops, justifies more expensive methods. Undoubtedly, steam or hot water is the most effective method of ridding the soil of nematodes, and where the trucker has steam handy it is undoubtedly the most satisfactory method of treating seed beds, but unless the land is piped for steam we have found steaming a very expensive process. It was tried on the pineapple lands of the East Coast but the cost was prohibitive. The same objection applies to hot water. The expense involved was largely that of transporting the boiler or other outfit from place to place.

We have tried carbon bisulphide and formalin and find them very good soil fumigants for nematodes, but on the whole we have had the best success, considering the cost, with a double treatment of sodium cyanide and ammonium sulphate. This was first tried, so far as the speaker knows, a number of years ago in California by Professor Woodward on a small scale. In practice, the soil is first saturated with a solution of sodium cyanide in water. We find that the dosage required will vary much with the type of soil. In general the lighter the soil the smaller the dosage required. On the sandy soils of the average trucking regions of Florida we have found that 600 pounds of sodium cyanide per acre is usually sufficient. This is applied in water and washed down with a liberal irrigation (most seed beds in Florida are provided with overhead irrigation.) Ammonium sulphate is then added at the rate of 900 pounds to the acre. This is also washed down with a light irrigation. The ammonium sulphate acts on the sodium cyanide producing hydrocyanic acid gas. We find this method very effective, not only in killing out the root-knot organisms, but all animal life in the soil is killed. The seeds of most weeds are also killed, but those with large, heavy seeds will usually survive the treatment, as will also heavy Bermuda grass sod. Of course, covering the ground with some gas tight material, such as tarred paper or a cloth treated with

rubber (we have found the material from which the tents for fumigating citrus trees are made to be very satisfactory) will greatly increase the killing effects of the fumigation and reduce the dosage necessary.

The expense of this treatment is high. It costs nearly $200 per acre, but as the acreage is usually small the above expense is not prohibitive for seed beds. The residue, of ammonium sulphate, left in the soil increases the soil fertility and causes rapid growth of the plants.

We find that we can ordinarily safely plant the soil in ten days to two weeks after treatment. We have tried the sodium cyanide alone without the ammonium sulphate but the results were not nearly as satisfactory. The evolution of gas was not sufficiently rapid and the cyanide remained in the soil for a considerable time. It was difficult to get rid of it.

We are now experimenting with calcium cyanide, both in the form of dust and flakes. It would seem that we will be able to substitute this material for the sodium cyanide and ammonium sulphate at a greatly reduced cost. We have found the most satisfactory method of applying this material is to sprinkle it in the furrow when the land is plowed.

Drowning

It has long been observed that lands regularly kept under water for several months each summer were never seriously affected by nematodes. The flooding of the Everglades last year offered us opportunity to secure some data on the length of time necessary for eradication of nematodes. We found that soils continually under water for as much as six weeks still had plenty of nematodes, but fields submerged for four or five months were in all cases free. It would seem as if the time necessary to drown out the nematodes is too long to make this method of much practical benefit.

Mr. R. A. Cooley: I would like to ask if the cyanide treatment of the soil had any effect on the soil organisms?

Mr. J. R. Watson: It did not seem to have much effect.

Mr. H. F. Dietz: I would like to ask Mr. Watson if he has had any experience in getting perennial plants to outgrow the nematodes. This is a problem which I think will be important in the next few years, especially in connection with hardy perennials.

Mr. J. R. Watson: We are running tests along these lines but thus far they have not been very satisfactory.

MR. E. W. BERGER: A little test that I made in 1922 may serve as a near-answer to Mr. Dietz's question. I had trouble with Root-Knot Nematode severely infesting a few rows of Swiss chard in my garden. I transplanted several small plants into two flower-pots, being particular to select plants equally infested, and used infested soil from the same spot in the garden.

The soil in one pot was regularly drenched (perhaps, on an average, once per week) with a one-tenth per cent solution of glacial acetic acid in water (later 2-tenths per cent was used), while the soil in the other pot was always drenched only with an equal amount of plain water. Both were treated alike as to fertilization.

It was soon apparent that the plants receiving the weak acid were doing much better. When, after several months (February to June, 1922), the plants receiving only water died, examination showed that the treated plants had developed an abundance of apparently healthy rootlets, which was not the case with the plants that had received only water. The treatment had evidently checked the development of the nematodes in the soil, allowing the development of healthy or nearly healthy rootlets, whereas the roots of the untreated plants were unusually full of nematode-knots.

MR. W. E. HINDS: For a number of years we have used sodium cyanide solution alone, particularly in treatment of green house soils, with fairly satisfactory results so far as the control of nematodes is concerned, and with beneficial results so far as the growth of vegetation is concerned. This treatment is practicable with lettuce, squash, and crops like that of a truck nature. Its use would seem to be justified entirely from the fertilizer standpoint alone. Planting just as soon as the soil is dried out enough to plant any seed has seemed to be safe. A solution of 1 oz. sodium cyanide in 8 gallons of water is applied at the rate of 1 gallon per square foot of area.

PRESIDENT A. G. RUGGLES: The next paper will be read by Mr. K. C. Sullivan.

THE USE OF CALCIUM CYANIDE FOR THE CONTROL OF FLEAS AND OTHER INSECTS

By K. C. SULLIVAN, *Columbia, Mo.*

ABSTRACT

Calcium cyanide was successfully used for the control of the Dog fleas (*Ctenocephalus canis* Curtis) and the Human flea (*Pulex irritans* L.) in both open and closed buildings. Calcium cyanide used at the rate of four ounces per 100. sq. ft., will

give practically 100% kill in closed buildings. Eight ounces to 100 sq. ft., in open buildings will give the same results.

Calcium cyanide dust was successfully used for controlling blister beetles (*Epicauta vittata* Fab.), in gardens.

Used at the rate of one ounce to 1500 cu. ft., of space, calcium cyanide dust gave a 95% kill of white fly (*Aleurodes vaporariorum* Westw.) in greenhouses without any injury to plants.

Calcium cyanide dust gave fair results when used at the rate of one ounce to 25 cu. ft., one ounce to 50 cu. ft., and one ounce to 100 cu. ft., for periods varying from 45 minutes to one hour, for the control of San Jose scale (*Aspidiotus perniciosus* Comst.) on nursery stock, apple and peach.

During the past year calcium cyanide has been used at the Missouri Agricultural Experiment Station for the control of a number of different insect pests. Due to the fact that Calcium cyanide is a new product most of the work with it up to the present time has been purely experimental. However, in a number of cases it has been used with very great success in a practical way and on a large scale. The results which have so far been obtained lead us to believe that calcium cyanide has many possibilities and that in the future it can be safely and successfully used for the control of not only certain insect pests but also certain other types of animals such as rodents which destroy annually large quantities of agricultural products. It must be remembered, however, that its use as a remedy for controlling insects is still largely in the experimental stage. In most cases methods of application must be worked out and the dosage necessary to kill particular insects determined. In other words, from the standpoint of an entomologist there are many things which we do not know about calcium cyanide. Therefore, in this paper I shall attempt only to point out some of the possibilities of calcium cyanide when used for the control of fleas and other insects and give a brief resume of the results which have been obtained during only one seasons work. Additional work may, and I believe will, substantiate the results which have been obtained, but on the other hand further experiments should be carried out before definite conclusions are drawn.

Calcium cyanide being a material which gives off hydrocyanic acid gas, one naturally infers that it can be used for fumigating purposes. It may be obtained in three different forms—flakes, granules and dust.

On coming in contact with moisture either from the air or the soil the hydrocyanic acid gas is given off. All of the different forms are easy to handle and where it can be successfully used the process of fumigating is greatly simplified. In some instances it is more desirable to use the

dust form than either the granules or the flakes, as the hydrocyanic acid gas is given off more rapidly from the dust.

During the past summer fleas were very plentiful in Missouri especially through the central portion of the state, with the result that ample opportunity was offered to make some rather extensive tests with calcium cyanide. The credit for the work with fleas is largely due Mr. S. W. Bromley. This work was carried on in cooperation with the Department of Entomology of the Missouri Agricultural Experiment Station.

The first test made was in a modern dwelling house in Columbia, Missouri on July 20, 1923. An Airdale dog was allowed to sleep on the second floor with the result that this floor became badly infested with the dog flea (*Ctenocephalus canis* Curtis). After the infestation was discovered the dog and two cats were kept out doors. The floors were new and of hard wood. The fleas were evidently in the rug, and upon entering this floor numbers of the pest would jump upon the trousers. No fleas were observed in any other part of the house.

The house was fumigated with calcium cyanide flakes at the rate of 4 ozs. to 100 cu. ft. on the second floor where the infestation was present, and one ounce per 100 cu. ft. on the first floor and the basement. The flakes were put down at 8:30 in the morning, the house emptied of its inhabitants and all the windows and doors closed. The flakes were scattered on newspapers on the second and first floor and on the concrete floor in the basement. Flakes were also scattered outside in the new sleeping quarters of the cats and dog, and the animals were treated with kerosene emulsion.

At 5:30 P. M. the house was opened and the newspapers and flakes removed. The flakes were still giving off some gas. A number of dead fleas were shaken from the rug in the badly infested room. During the next few days three or four fleas were found in clothing which were evidently brought in from the outside. No further trouble was experienced and the owner was well satisfied with the results.

Similar results were obtained in the basement of a store in Columbia, Missouri. The owner kept a dog in the basement and it became so badly infested that he feared the fleas would find their way up stairs and attack his customers. The basement was tightly closed and the door fixed so it could be opened from the outside. At 7:30 P. M., July 26, 1923, flakes were scattered on the concrete floor at the rate of two ounces to 100 cu. ft. The place was opened the next morning at

7:30 and no live fleas could be found. The dog was taken to the country and the owner had no more trouble.

The space under the porch of a dwelling house in Columbia, Mo. became infested with fleas from a dog which bedded there. The owner spent a few minutes under this porch one day examining some pipes and afterwards killed twenty-two fleas on his clothing. The dimensions of the space under the porch was ninety square feet. At 4:15 P. M. August 1, 1923 a little less than two pounds of 50% calcium cyanide dust was uniformly scattered. Three days later no fleas could be noticed under the porch but upon examining a quantity of the debris in the laboratory one live flea was found.

The barns, sheds and hog houses on a farm near Columbia, Mo. became very heavily infested with the human flea (*Pulex irritans* L.) The fleas were so bad that the owner had trouble keeping hired help. Calcium cyanide flakes were scattered by hand at the rate of four ounces to 100 sq. ft. on newspapers which had been spread down in the different buildings. The flakes were put down at 7:30 P. M. July 24, 1923. The newspapers were used so that the residue could be easily cleared away as poultry and hogs had the run of most of the buildings. Wherever possible the buildings were closed but some of the sheds were open on one side. There was no breeze. Conditions were as nearly ideal as possible. The next morning the premises were carefully examined and no living fleas were found except in the tool shed. In this building a few had survived. The application was repeated in this building using eight ounces to 100 cu. ft. Not a single living flea could be found one hour later.

Calcium cyanide used at the rate of eight ounces to 100 sq. ft. can be depended upon to give practically a 100% kill. In a building which can be closed, four ounces to 100 sq. ft. will give the same results.

Some interesting results were also obtained in using calcium cyanide for the control of blister beetles on garden and truck crops. Tests were made with the 50% dust on the striped blister beetle (*Epicauta vittata* Fab.). This blister beetle made a sudden attack on a small garden of about 255 feet square. They were feeding heavily upon beets, and potatoes. A knapsack duster was used and the application was made at about 4:00 P. M. on July 27, 1923. About two pounds of dust was used. Most of the beetles were killed almost instantly. Some, the gas seemed to paralize. First, the rear pair of legs became useless. The beetles would try to pull themselves along with the first two pair when shortly the second pair would cease to function. Then

in a short time the first pair of legs would become useless. The antennae seemed to be the last organs which were affected. Naturally a few of the beetles escaped before they got enough gas to stop them, also a very small number of the beetles revived enough to crawl away. The garden was examined the following morning. Some of the beetles on the ground were still able to slightly move their legs and antennae. A number of these were collected and brought in the laboratory .Twenty-four hours later they were all dead. Very few of the beetles escaped and the injury they did to the garden was slight. Similar results were obtained in every case where calcium cyanide dust was used for the control of blister beetles.

A few tests were made with calcium cyanide on squash and melon vines for the control of the striped cucumber beetle (*Diabrotica vittata* Fab.), and the squash bug (*Anasa tristis* DeG.). Calcium cyanide flakes used at the rate of one teaspoon per hill killed both the insects and the plants. The granules and the dust gave the same results. Equal parts of calcium cyanide dust and air slacked lime used at the above rate showed no injury to the plants but did not give satisfactory control. However, from the results obtained it seems probable that it will be possible to work out a dosage which can be used satisfactorily for the control of melon pests.

Plant lice succumb quickly to very small quantities of calcium cyanide dust. The dust was successfully used on melons and on Spiraea Van Houtti. It was applied with a small hand bellows. The aphids were almost instantly killed and without injury to the plants.

Recently the Department of Horticulture of the Missouri Agricultural Experiment Station has been depending upon calcium cyanide dust for the control of the white fly (*Aleurodes vaporariorum* Westw.) in their greenhouses. The results have been entirely satisfactory. It was first used last May in a greenhouse containing young tomato plants which were badly infested with white fly. The house contained 7758 cu. ft. of space. Eleven ounces of dust was used. It was evenly distributed on the beds thruout the house and some of the dust was placed directly on the leaves. The application was made at 6:10 P. M. May 23, 1923. The house was opened the next morning at 4:35. All adult flies were dead. Most of the larvae and eggs were killed. The pupa appeared to be alive. Seven days later several adults had emerged from the pupa and the few eggs which had not been killed were hatching. Where the calcium cyanide came in contact with the leaves it caused serious

burning, otherwise the plants were not injured. It requires two treatments to thoroughly clean out an infestation of white fly.

A greenhouse containing over fifty different kinds of plants was fumigated December 17, 1923 using one ounce calcium cyanide dust to 1,000 cu. ft. A 95% killl of white fly was obtained and no plants were injured. A temperature of 60 F. was maintained and the house was allowed to fumigate from 7 P. M. to 7 A. M. Calcium cyanide dust used at the rate of one ounce to 2,000 cu. ft., temperature 60° F., gave a 25% kill. The ease and safety with which calcium cyanide can be used seems to indicate that it has possibilities of becoming the standard remedy for the control of white flies in greenhouses. Its effect upon other greenhouse pests has not as yet been studied.

On November 13, 1923 a series of experiments were started to determine the value of calcium cyanide for fumigating nursery stock infested with San Jose Scale (*Aspidiotus perniciosus* Comst.), apple and peach trees were used. The apple trees had two seasons growth from graft, the peach trees were cut backs but with two seasons growth. They were grown in an experimental nursery and were badly infested with San Jose Scale. Many of the peach were almost encrusted. A tight fumigating box was used. Calcium cyanide dust was used at the rate of 1 oz. to 25 cu. ft.; 1 oz. to 50 cu. ft.; 1 oz. to 100 cu. ft.; 1 oz. to 200 cu. ft. and 1 oz. to 400 cu. ft. Five sets of trees were used for each strength. The first set was allowed to fumigate for 30 minutes; the second 45 minutes; the third 1 hour; the fourth 1¼ hours and the fifth 2 hours. The trees were dug and placed directly in the fumigating box. The desired quantity of calcium cyanide dust was then spread out on a dry board placed in the center of the box about half way between the bottom and top. After fumigating the trees were reset, and ten days later the first counts were made. With every test enough scales were counted to get a fairly accurate average of the percentage of scale killed. The first or the ten day count showed that none of the treatments resulted in a 100% kill. In one case (1 oz. to 200 cu. ft. for 30 min.) only 70% of the scales were dead but in most cases the kill was better than 90%. About three weeks after fumigating counts were again made on the first three sets of trees. This time 100% of the scale were dead in eight out of fifteen cases. Then again about five weeks after fumigating the third counts were made on all of the twenty-five different tests. Live scales were found only on nine. The following table shows a complete record of all counts made and the results obtained.

THE USE OF CALCIUM CYANIDE FOR THE FUMIGATION OF PEACH AND APPLE TREES FOR SAN JOSE SCALE

Amount of material used	Date of treatment	Date counted	Kind of tree	Percent scale dead for different periods of treatment: 30 Min.	45 Min.	1 Hr.	1½ Hrs.	2 Hrs.
1 oz. to 25 cu. ft.	11/13/23	11/23/23	Peach	90.5	94.5	96.4	99.3	83.5
	11/13/23	11/30/23	Peach	96.5	99.0	96.5	99.0	94.5
			Apple		100.0			
	11/13/23	12/21/23	Peach	100.0	100.0	100.0	98.5	100.0
			apple		100.0	100.0		
1 oz. to 50 cu. ft.	11/16/23	12/26/23	Peach	83.3	90.0	94.0	96.8	96.8
			Apple		100.0			
	11/16/23	12/6/23	Peach	91.0	100.0	100.0	96.8	98.5
			Apple	99.2				
	11/16/23	12/20/23	Peach	100.0	100.0	99.5	100.0	100.0
			Apple	100.0	100.0	100.0	100.0	100.0
1 oz. to 100 cu. ft.	11/17/23	11/28/23	Peach	98.6	95.0	90.5	91.7	96.5
			Apple		96.0		92.3	
	11/17/23	12/7/23	Peach		100.0		100.0	94.5
			Apple	100.0	99.0	98.6	100.0	
		12/20/23	Peach		100.0	98.6	100.0	100.0
			Apple	100.0	100.0	96.8	100.0	100.0
1 oz. to 200 cu. ft.	11/20/23	11/30/23	Peach	70.0	87.0	93.9	70.0	95.0
			Apple	97.0		93.5		96.0
	11/20/23	12/20/23	Peach	93.5	97.5	99.0	100.0	100.0
			Apple	98.0	100.0		100.0	
1 oz. to 400 cu. ft.	11/24/23	12/6/23	Peach	97.0	50.0	97.7	100.0	95.5
			Apple			86.2	99.0	100.0
	11/24/23	12/20/23	Peach	82.0	68.1	93.7	100.0	100.0
			Apple	54.7		100.0	100.0	100.0
Check..		12/28/23	Peach Percent Scale dead 62.9					
			Apple Percent Scale dead 53.3					

From the results one would naturally draw the conclusion that calcium cyanide kills slowly. However, on the first counts made wherever it was doubtful whether a scale was alive or dead it was considered as a live individual. At the time when the last counts were made there was no question about the live or dead individuals. They were easy to distinguish. This probably explains the difference in the percent of kill between the first and last counts. Also the results seem to indicate that calcium cyanide used at the rate of 1 oz. to 100 cu. ft. will give just as good results as when used at the rate of 1 oz. to 25 cu. ft. The thirty minute treatments gave just as good results as the two

hour treatments at the above strength. With the weaker concentrations the period of fumigation must be lengthened as one ounce of calcium cyanide to 200 cu. ft. and to 400 cu. ft., gave 100% kill only for the 1½ and the 2 hour periods.

The writer has done considerable work with both potassium cyanide and sodium cyanide in the control of scale insects on nursery stock and the results so far obtained with calcium cyanide are practically as good as those which have been obtained with the other materials. However, the writer is not ready to fully recommend calcium cyanide for fumigating nursery stock until additional data have been obtained as to its effect both on the scale and on the plants.

It is hoped that others will pursue the work with calcium cyanide. It undoubtedly offers great possibilities and if additional experiments show that it can be successfully used for fumigating nursery stock the process will be greatly simplified.

QUESTION: I would like to ask the speaker how they applied the cyanide to the green house. And also on peach trees.

MR. K. C. SULLIVAN: In greenhouses, we scattered it on newspapers. We have scattered it on the soil, and it works all right. It can be removed very quickly if placed on newspapers.

MR. J. R. WATSON: I would like to ask if the larvae of the white fly are not killed?

MR. K. C. SULLIVAN: No, it takes two treatments to get the white fly.

MR. J. R. WATSON: We didn't have good results killing larvae.

MR. L. O. HOWARD: Did you have any accidents?

MR. K. C. SULLIVAN: Not in this work on fleas.

MR. D. L. VAN DINE: I'd like to ask the period of exposure.

MR. K. C. SULLIVAN: We usually put it in in the afternoon and take it out in the morning, or put it in in the morning and take it out at night,—about twelve hours.

QUESTION: I'd like to ask Mr. Sullivan to what extent cyanide treatment was used on cucumber beetles?

MR. K. C. SULLIVAN: We used the flakes, the granules and the 50 per cent dust, but we killed the plants in every test we made, except with the 50% dust. Our tests weren't over a very large scale, however, and it is rather hard to draw definite conclusions from the tests we made.

Session adjourned at 12:30 p. m.

Afternoon Session, Tuesday, January 1, 1924

The session convened at 1:30 o'clock.

PRESIDENT A. G. RUGGLES: The first paper on the program is by V. I. Safro.

THE PRICE OF INSECTICIDES

By V. I. SAFRO, *Clarksville, Tenn.*

ABSTACT

A practical discussion from the standpoint of the salesman and manufacturer designed to assist the purchaser and aid in producing more satisfactory conditions.

When fruit growers demanded that the economic entomologist include with his spraying directions for insect pests information covering applications for fungus diseases, the Plant Pathologist and the Chemist were called into collaboration with the result that the day of spray combinations arrived and today the grower can obtain full directions for an entire season's spraying. Combinations and compatibilities are authoritatively recommended as a result of competent investigations. This development may, perhaps, be considered the greatest recent step in the progress of entomological economics.

It may now be considered proper to suggest that the time has arrived when the economic entomologist can profitably take counsel with the business economist. Large numbers of publications are appearing with the express purpose of teaching the grower cheaper methods of controlling insect pests. The entomologist, notwithstanding his sincere desire to improve the farmer's economic condition, very often proceeds to violate those very principles of economics that he should carefully observe.

Investigators who carefully weigh every entomological fact and word before they permit its publication will too often give voice quite thoughtlessly to economic opinions—and it is the object of these remarks to call attention to this situation—though in doing so, portions of this discussion must necessarily be elementary.

Often the term "prohibitive" appears in publications relative to a consideration of costs of insect control. There is no clear understanding among entomologists of the meaning of this term. When does the cost of insect control become prohibitive to the grower? The writer in a paper in the JOURNAL OF ECONOMIC ENTOMOLOGY some years ago[1] indicated that under certain conditions the total expense of a spraying

[1]Journal of Economic Entomology, Vol. 10, No. 6 p. 521—Dec. 1917.

program may be greater than the value of the crop and still be not only not prohibitive but economically obligatory.

What is meant by "cheaper insecticides"—another term that is very frequently used and regarding which there is considerable uncertainty as to its meaning. There must, of course, always be a search for cheaper insecticides; and furthermore, the search for new insecticides must continue regardless of present prices of materials.

Home manufacture is frequently suggested. If a fruit grower can save fifty percent of the cost of lime-sulfur by making it himself rather than by purchasing the manufactured article, is it necessarily a cheaper insecticide to him? Assuming allowance has been made for the labor value of the growers time, the fuel in cooking and such other usual items of expense that must necessarily be included in any study of comparative costs, another factor of considerable importance is yet to be reckoned with—and a factor that is too often entirely overlooked—this is the factor which for the lack of a more accurate name may be called "convenience."

The economic factor of convenience must not be underestimated. It is the direct motive for that specialization in human activities that is characteristic of modern civilization. What is its value to the individual? Its value is exactly what that individual is willing to pay rather than have to do without.

An attitude of resentment can at times be detected on the part of the present generation of farmers toward the reactionary tendency of agricultural writers to base their recommendations on premises that were not questioned several generations ago; and it is proper for the farmer today to resent the assumption that he is not a seeker after comfort—whatever that term may imply—or that his economic ideas are so undeveloped that he is willing to place his bodily labors always lowest in the scale of economic values.

This factor is repeatedly ignored in official publications. The modern American idea of contingent success is independence. This may mean an opportunity to be lazy, it may mean an opportunity to ride a hobby, but whatever it does mean the underlying thought is that it places the individual in a position where he does just what he pleases to do even though the fact of its pleasure may depend upon whether the work in question is voluntary or obligatory.

When a grower is strongly urged to make his own lime-sulfur it may not always solve matters to suggest that this can be done during the winter, and therefore, should be undertaken by the farmer in order to

fave the few extra dollars that would otherwise go to the manufacturer or relieving him of this work. Directions for home manufacture should, of course, be included for those who are in position to undertake such labor and the recommendations would not be complete unless they were. But directions are equally incomplete when they ignore those growers who prefer to purchase the finished article.

To suggest to a farmer in this connection that he is not using his time to best advantage may give rise to a reaction that may find expression in the farmer's rejoinder that he is sole judge of what it is he most prefers to do. This attitude must not be contrasted with the desire on the part of growers for information as to improved methods, but refers entirely to the assumption that is too often urged upon the grower that whatever he can make himself is necessarily cheaper than anything he can have made for him.

It is in this connection that the economic entomologist can profitably collaborate with the business economist. The problem is not materially modified by stating that as between the grower making a preparation of his own and the factory making one, there are a number of intermediate steps, consisting of the hire of laborers to relieve him of the manual labor —incidentally, perhaps, increasing the responsibilities and opportunities for additional inconvenience. It is for each grower to decide whether he will make a certain preparation or purchase it ready made and the agricultural writer must not take the attitude of dictating the choice. In passing, it is proper to remark that labor in many parts of the country is scarce and must be humored, hence the item of comfort and convenience may apply also to the individual's hired men.

The first thought in the endeavor to obtain cheaper insecticides is often this one of home manufacture. The next evident thought that arises is the desirability of developing other materials or combinations that are not being used at present for that purpose. The opportunities for proper economic guidance in this desire are particularly plentiful.

Assume that a cheaper insecticide is desired for the control of certain pests. It is, of course, first highly advisable to know the cost of the insecticide that it is intended to replace. With this first premise the investigator too often begins in error. Unfortunately, the average entomologist has not the time to ascertain the prices *current* on insecticides, and without this information it is difficult to conduct with any degree of accuracy a study of comparative costs as between an insecticide in use and one in prospect. Nor does it answer the question to inquire of the local dealer the prices of the particular insecticides that he is

handling. It is normally equally unsatisfactory to write to the manufacturer and inquire as to the prices of his insecticides. For competitive reasons, a manufacture may prefer not to reveal his schedule of prices to a non-purchaser.

Except in cases of proprietary preparations or materials having a limited or controlled output, the matter of ascertaining the price of an insecticide is not as simple as is too often taken for granted. The following factors may be suggested as effecting the prices of competitive insecticides and must be included in the matter of price consideration:

There may be a distributor's or jobber's schedule of prices and a retailer's schedule of prices. Each of these factors normally retains for itself a profit. The freight rates on raw material to the factory and the finished product to different consuming districts may effect prices, sometimes considerably. Seasonal sales variations affect prices of commodities normally and insecticides as a class are no exception to such variations. Normally the season of least sales activity with a competitive insecticide would be expected to coincide with the season of lowest quotations. However, this would in turn be affected by such factors as visible and prospective supplies. There are times when the demand is practically nil but the price is maintained because stocks are low. This condition might be susceptible to change if sufficiently large tonnages of insecticides were to move at what is ordinarily the inactive season.

The quantity item in ordering must not be overlooked as a price factor. Some concession can be expected where orders are in larger amounts, where packages are larger in size or even where the greater number of smaller packages are shipped on the single order. This gives the larger purchaser the advantage and whether or not this advantage is passed on to the ultimate consumer is entirely a matter of business relationship between the lot purchaser and the ultimate consumer.

A very important factor affecting the price of insecticides is the manner of payment. A cash payment will very often bring a discount. It is especially important in a consideration of prices that the value of this discount be not underestimated. When interest on borrowed money amounts to from six to eight percent per annum, it is a matter of simple arithmetic to figure out the profit return on a cash discount of two percent for payment in ten days, assuming that the net account is due, say, in thirty days. Where growers' accounts are carried until the end of the season the price factor is further complicated, but the underlying fact must be borne in mind that borrowed money must be

paid for whether the borrowing takes the form of credit extended by a dealer for the purchase of goods or whether the money is actually rented by the borrower. *Very often, cheaper insecticides can be obtained by the grower by a rearrangement of his methods of payment.*

The general credit standing of a prospective or actual purchaser is also a factor. A prospective purchaser who is known to pay his bills when due, ordinarily has an advantage over the purchaser whose credit standing is not satisfactory and he can, at times, obtain lower quotations.

This discussion does not necessarily imply that each purchaser can receive the benefits of all these items as regards his own individual purchases, but it indicates the economic lines along which cheaper insecticides may be obtained.

While these factors refer more evidently to competitive materials, the principles apply, in general, even in the case of non-competitive products. One of the economic functions of a proprietary substance is to remove it, as far as possible, from competitive price behavior. A brand name for a compound often sells it at a higher price than the chemically identical compound purchased as a chemical substance.

Because of lack of sufficient information, the chemical designation of an insecticide cannot always be adopted; but serious consideration, with especially full collaboration of the chemist, should be given to the problem before decisions are made. Consideration should include not only the usual biological and chemical limits of error but also manufacturing variations, which may be greater within the one brand at one time than as between different brands at other times. The history of the development of arsenate of lead exemplifies this principle.

We grant we have ascertained the prices of a certain insecticide and we have discovered a substitute that is composed of ingredients which when properly combined and properly used will have the same or better effect at apparently a smaller expenditure of money on the part of the grower, or perhaps leave a greater profit in its adoption even though the apparent price be greater than the known material or the efficiency be less. This latter item is very important. The fact that one compound yields 95% control and another only 85% control does not of itself justify confining recommendations exclusively to the former substance. That same factor of convenience enters here, together with the other evident economic factors such as cost and efficiency of labor and its supply, the availability of the material and perhaps the limit of choice between 85% control and none. This status is met with in a number of instances where dusting is not as effective as spraying in

the control of pests and yet is the most economical and at times the only method that can be adopted.

The warning underlying this thought is not to discard the inferior method of control without full consideration of all economic factors that may be concerned.

Assuming that the new insecticide seems to have an advantage in price over the old, what are some of the factors that must be considered in order to obtain an idea of its comparative advantage in price to the consumer and to save the investigator from making economic claims that may not materialize.

To begin with, someone must financially sponsor the new material. No matter how simple it seems or how evidently successful it may soon become, someone must risk his money in the venture. It may at this point not be out of place to mention that notwithstanding the greater development of the insecticide industry in recent years, after all it is a small industry compared to those world industries that the general public comes into contact with every day. The insecticide industry is difficult for capital to understand and with capital's well known timidity, it may be mentioned that it is not particularly anxious to rush into the insecticide business, especially when it is understood that, with only a few exceptions, the industry has not been a particularly profitable one. The mistake must not be made of thinking that the funds, equipment and energy of manufacturers already in operation constitute capital any the less for that reason.

Granting that funds have been obtained with which the new development can be undertaken. There is a charge, then, against the new insecticide as a return to capital for its use. This is not to be confused with the manufacturing profit that is expected in the conduct of a manufacturing plant. The return to capital for its use must be greater than normal interest returns. There is considerable risk and uncertainty in all business ventures, and the insecticide industry has been no exception to past experience that 95% of all business ventures fail. Hence, capital has a full right to expect return in proportion to the risk involved.

Having obtained financial backing, it is necessary to figure on expense of equipment and installation, on the cost of production, being careful to allow sufficient margin to make up for the under-estimates that practically always occur in such cases, as well as for usual wastages, and for overages in quantities and analyses necessary in fully complying with the laws. It is, of course, assumed that the production of the new material will

be on a sufficiently large scale to justify its existence. The simplest type of a manufacturing venture would be for one man to make the material, assuming it could be done on a one man scale. The amount of business would have to be sufficiently large to pay this man for his time and efforts and such pay, as well as all other charges, must come out of the price of the material. This becomes increasingly significant in the case of larger organizations.

It is not always an easy task to convince directors of corporations that they are justified in authorizing considerable expense for development which will of necessity be gradual. A new discovery in the insecticide world is not immediately adopted. In fact, entomologists have so much work to do, and it is so specialized, that they are not always able to keep fully informed as regards the new developments in their own profession. And if this is true, how less likely is it that dealers will purchase the new material—and the local dealer is often the overlooked limiting factor in the use of an insecticide.

The manufacturer must make a profit. Otherwise he ceases to exist. He must make a profit sufficient to overcome not only the manufacturing difficulties but expenses attendant upon selling and distributing his product. After the manufacturer comes the first purchaser; if there is a distributor he receives a profit; the jobber receives a larger profit and the retail dealer the largest of all. Retail dealers as a class do not like to handle agricultural insecticides for less than a 20% profit. All of these items must be included in the price of the prospective insecticide.

Finally, having estimated the probable price to the consumer of the new insecticide compared with the old one, under similar conditions as to the quantity, season, method of distribution, etc. Other queries arise. Will entomologists acquaint themselves with it? Will the consumer buy it? How much money will it take for advertising and other educational work to interest the consumer? Will the dealer handle it, so that the consumer can purchase when he wants it? The expense of this type of work must also come out of the ultimate price.

These remarks are not to be interpreted in any way as discouraging the search for new insecticides. On the contrary, it is an effort to indicate some economic factors, consideration of which should assist in the logical development of new insecticides.

This discusssion will also help to explain why the entomologist's estimates of the probable ultimate cost of a new product almost always falls far below the final cost to the consumer of the manufactured article. It may also put to final rest that old school suspicion that all insecticide

manufacturers are endeavoring to obtain unreasonable profits in the sale of their products.

The economic entomologist must be constructive and these remarks should include economic suggestions in answer to the universal inquiry "How can we get cheaper insecticides?" In partial reply the following are suggested:

1. Avoid the too frequent tendency to give the fewest methods of control. Give *all* the methods where feasible, explaining the limitations of each, so that the grower may choose for himself what, under his conditions, he considers most economical. This suggestion is intended also to give a grower other alternatives when he cannot, for one reason or another—sometimes very trivial, yet cogent—follow the best method of control. A method of partial control, if profitable, is more desirable than no control.

Include methods of farm manufacture but not to the exclusion of the factory made chemicals. As between farm manufacture and the factory made article on the one hand and the choice of a number of methods of control on the other, a status of competition may be fostered, and this is the powerful economic regulator of prices.

2. Promote group purchasing where practical. This does not necessarily imply displacing the local dealer by formation of growers' purchasing organizations. The local dealer may be in better condition to supply requirements than an organization that may be lacking in merchandising experience. The advantage in purchasing large quantities applies to purchases from the local dealer as well as purchases that would contemplate supplies direct from the manufacturer.

3. Promote the taking of cash discounts and building up of good credit standing. Where the grower has not the available funds himself, arrangements can often be made through the agency of a bank on a basis where both the bank and the grower receive benefits of the discount.

4. Promote early and off-season purchases. An order can frequently just as well be placed six months ahead of time for delivery at the growers' convenience as the present uneconomic method of waiting almost to the last minute before ordering—and paying sometimes dearly for that privilege.

VICE-PRESIDENT FRACKER assumed the chair.

VICE-PRESIDENT S. B. FRACKER: The next paper is to be read by Mr. S. C. Chandler.

SOME RECENT DEVELOPMENTS IN THE USE OF PARADICHLOROBENZENE

By S. C. CHANDLER, *Illinois State Natural History Survey*

ABSTRACT

Experiments and observations on the peach borer, *Aegeria exitiosa* Say, in Illinois during the past four years have brought out the following facts about paradichlorobenzene.* 1. Grass and weeds need not be removed from around the base of the tree before applying the chemical. 2. Heavy rains just before or just after treatment do not appear to effect the action of the gas. 3. One year trees have not been injured when treated with P. D. B., in the proper manner. 4. It is not necessary to remove dirt from around the trees after treatment. 5. Up to the present time, there have been no injurious cumulative effects of P. D. B., in Illinois. 6. P. D. B., packed closely against the bark of young peach trees will kill a large percentage of the trees. 7. No injury was produced by P. D. B., in experiment with apple trees. 8. 2 oz. application per tree is suggested as advisable for 12 year old trees.

As a result of four years of experimental work and observation in southern Illinois, some new and interesting conclusions have been reached on the use of paradichlorobenzene[1].

REMOVAL OF GRASS AND WEEDS

The common practice of scraping away grass and weeds from around the bases of peach trees before treating with P. D. B., is open to two objections, viz., it takes too much time, and there is a tendency to scrape away so much dirt that the chemical is applied below the point where some of the borers are feeding. This latter point is brought out in Table 1, which shows only 64% kill where applied too low.

Experiments to determine the necessity of removing grass and weeds before applying P. D. B., were begun in a small way in the fall of 1922, and followed up in the spring and fall of 1923. Trees 5 years old were selected for this purpose, in uncultivated and uncared for orchards in order to secure an excessive amount of grass and weeds, more than would usually be encountered.

By referring to Table 1, it will be observed that in 4 out of 5 trials during the three seasons in which the experiments were carried on, as good results were obtained where grass and weeds were not removed as where removed. The percentages of kill varied from 92% to 100% where not removed, and 79% to 100% where removed. In the course of these experiments a fact was brought out that I have observed every year in experimental work with this material, that worms killed by the

[1]Paradichlorobenzene, for convenience sake, has been called P. D. B., (Painless Death to Borers).

gas decay rapidly, and if treatments are left for from 4 to 6 weeks before examinations are made, few dead worms are found, though live larvae are usually easily located. To be conservative, however, I have not based my percentages of kill on the number in the check trees.

TABLE 1. A COMPARISON OF THE RESULTS OF P. D. B. TREATMENT ON PEACH TREES FROM WHICH GRASS, WEEDS, AND GUM HAD BEEN REMOVED PRIOR TO APPLICATION, WITH TREES IN WHICH THIS WAS NOT DONE.

Treatment Applied	Examined	No. of trees	Removed Live	Removed Dead	% kill	Not removed Live	Not removed Dead	% kill
Oct. 12, '22	Nov. 13	6	0	2	100	0	3	100
Check	" 21	6				7	0	
May 23, '23	June 18	10	3	12	80	3	18	85.7
Check	" "	5				9	0	
Sept. 15, '23	Oct. 20-22	10	0	4	100	1	5	83.3
Oct. 1, "	Oct. 22	10	2	17	89.4	1	13	92.8
" 13, "	" 27	10	13	51	79.6	1	12	92.3
" " "	" "	10	5	9	64.2[1]			
Check	" 22	10				28	0	

[1]Dirt removed such that P. D. B. was applied at level lower than some of the burrows.

EFFECT OF RAINS

As the killing agent in P. D. B., is a gas which penetrates to the burrows thru the air spaces in the soil, it would be reasonable to expect that rains filling these air spaces would retard or prevent the passage of the gas, and that it would be useless to treat immediately after soaking rains; also that a treatment applied just before a period of heavy precipitation would not be very effective. To spread some light on the question, weather records were examined in connection with the experimental work of the past four years, and data compiled which is presented in Table II.

These data show eleven cases in which rainy periods of from 4 to 11 days, with precipitations averaging 3.19 inches, immediately preceded or followed treatments which gave kills of 77% to 85% in the springs, and 80% to 100% in the falls.

YOUNG TREES NOT INJURED

The first experimenter with P. D. B., advised against its use on trees younger than 6 years of age. Other workers in Eastern states have reported injury on young trees. Following these men, a number of writers have included in their recommendations the caution not to treat young trees.

TABLE II. EFFECT OF RAINS

Date of Application	Place	Rainfall In.	Period of Rainfall	% Kill	
May 15, 1920	Carbondale	3.97	May 16–21, six consecutive days of rain	77%[1]	
Sept. 1, 1920	"	1.23	Aug. 26–31, 4 days rain out of 6	100%	
Sept. 16, 1920	Farina	3.52	Sept. 8–15, 8 day period, with 7 days of rain	100%	
May 2, 1921	Anna	2.71	Apr. 26–May 2, 7 day period, with 5 days of rain	100%	
Sept. 28, 1921	Ozark	3.82	Sept. 24–27, 4 consecutive days rain	100%	Lot 1
				100%	" 2
Sept. 12, 1921	Anna	2.09	Sept. 1–11, 11 day period, 9 days of rain	100%	
Oct. 12, 1922	Carbondale	2.92	Oct. 6–11, 6 consecutive days of rain	100%	Lot 1
				100%	" 2
May 23, 1923	Ozark	4.27	May 12–19, 8 day period, with 7 days rain, then 3 days intermission, then	80%	Lot 1
				85%	" 2
		1.05	May 23–31, 8 consecutive days		
Sept. 1, 1923	Carbondale	3.01	Sept. 1–7, 7 day period, 6 days of rain	100%	
Oct. 13, 1923	"	5.57	Oct. 16–19, 4 consecutive days, following 2 dry days	80%	Lot 1
				12%	" 2

[1]Compared with 78% in dry period two weeks before.

Realizing that if this new material was to be of much value to the growers, it must be used on trees younger than 6 years old, we begun in the spring of 1920, with much trepedation, to treat 5 year trees. At first it was thought that some little injury resulted, as small, somewhat circular brown areas were found where the chemical might have affected the bark, but these areas were also found on untreated trees, both at that time, and every year since. Finding no apparent injury to 5 year trees, we moved our experiments in the fall of 1920 to 2, 3, and 4 year orchards, with equally good results. For the next two years, both fall and spring we treated 1 year trees, in no case causing injury. We usually used ¾ oz., per tree, but in two different orchards applied doses of 1½ oz., to blocks of 10, 1 year trees, with no ill effects.

Beside this experimental evidence, we have many acres of one year peach trees in Illinois which have been treated by the orchardists with no reports of injury.

The fact that young trees have not been injured in Illinois may be due

to climate or soil. There are two main types of soil in southern Illinois on which most of our orchards are located, the loess soils of the unglaciated hill lands, and the gray silt loam of the glaciated prairies.

Removal of Dirt From Bases of Treated Trees

In going over the recommendations for the use of P. D. B., I find it quite commonly advised to remove the dirt from around the bases of treated trees, after a period of from 10 to 14 days. To determine the necessity of this procedure we left undisturbed until spring a part of the trees treated in our first fall's experimental work in 1920. These trees

Fig. 7.—Peach tree ready for application of P. D. B. Grass and weeds not removed prior to treatment.

appeared to be just as healthy the following season as those examined the fall before. The caution to remove the dirt was not included in our recommendations, and as a result this has very rarely been done in Illinois. We have, it is estimated, two million peach trees in the commercial orchards of the State. At least a million of these have been treated, at some time, with P. D. B., and I have yet to hear of a case in which the dirt was removed. This includes such orchards as those listed in Table III, which have been treated for 3 and 4 consecutive years.

Cumulative Effects of P. D. B.

Altho we have no authentic record in Illinois of injury to peach trees from P. D. B., where applied in the proper manner, the question arises as to whether we can continue to use it year after year with no ill effects. Some data bearing on this point are given in Table III. This shows a total of 200 acres treated for 4 successive years and 115½ acres for 3 successive years, all with no ill effects. Ages of trees when treatment was first begun ranged from 1 to 10 years. The record of effect on trees was secured both from personal observation and talks with the owners.

Table III. Cumulative Effects of P. D. B.

Orchard	Place	Present Age—Yrs.	No. acres	Yrs. Treated	Effect on Trees
Amer. Fruit Growers	Cobden	3–12	200	4	No ill effects.
Paul Miller	Anna	5–7	50	3	" " "
J. C. Hundley	Carbondale	3	10½	3	" " "
John A. Gage	Texico	7	5	3	" " "
Guy Beauman	Tunnel Hill	7	50	3	" " "

The Effect of P. D. B. Touching the Bark

Users of P. D. B., have generally been cautioned against allowing the material to touch the bark of peach trees. In my own experimental work I have observed no injury when a few crystals have come into contact with the bark. To determine this point, four 1-yr. old trees were treated at Anna, in May 1922, using ¾ oz., per tree, packing it close against the bark. In July, these 4 trees were apparently as healthy as the other treated trees, but in September one was seen to be dying, and a dead area was found around the base of the trunk. At that time seven 1-yr. trees were treated in a similar manner at Ozark, Ill. In March, 1923, 6 of the 7 were observed to be dead at the base, tho the tops were still green. One of the seven was accidentally removed during the summer, but on September 12, the date of my last examination, 5 of the 6 were entirely dead, tho trees of the same age treated in the regular manner, were uninjured.

P. D. B. on Apple

To the writers knowledge the only experimental work on the use of P. D. B., on apple, (the results of which have been published) was carried on by E. B. Blakeslee in Springfield, W. Va., and recorded in U. S. D. A., Bul. 796. In this experiment 12 three year old apple trees

were treated, and all severely injured. Most of the smaller larvae of *Saperda candida* were killed, but the more mature specimens, working in the burrows, were still living.

In September, 1921, I treated six 8-yr. old Transparent apple trees at Ozark, Ill., with ¾ oz., P. D. B. A month later these trees were examined. A total of 7 live borers and 7 dead were found. As in the case above referred to, the live borers were usually those deepest in the wood, and especially those that had worked highest up. No injury, however, was observed, either at that time or later. This may possibly indicate that injury to apples by P. D. B., under conditions of soil and climate similar to those of southern Illinois, may not be feared, and it is recorded here in the hope that it may be of some help to future investigators of the subject.

Amounts to be Used on Old Trees

Our usual recommendation has been to use ¾ oz., for trees from one to five years of age, and I oz., for trees six years old or older. To ascertain the amounts needed on old trees, a portion of a 12 year old orchard was treated in Centralia, on Oct. 19, 1922, using 1 oz., 1½ oz., and 2 oz., respectively, with the following results:

10	trees,	1	oz.	totalled	27	worms,	23 dead,	or 85.5% kill.
10	"	1½	"	"	52	"	47 "	" 90.4% "
10	"	2	"	"	60	"	59 "	" 98.4% "
10	"	Check		"	101	"	0 "	"

These data, altho from but one season's work, indicate that it might be profitable to apply as much as 2 oz., of P. D. B., to trees of this age.

Mr. Alvah Peterson: I would like to ask Mr. Chandler if he has had any experience in treating peach trees in the nursery with this material.

Mr. S. C. Chandler: We have only tried it in the case of one or two trees.

Mr. J. J. Davis: I might say that we have used Paradichlorobenzene on nursery stock with apparently satisfactory results.

While I am on my feet, I wish to report the experiments which we conducted in Indiana in 1921 and 1922. We have been able to get just as good control in heavy sod as on bare ground, in the lightest sand soils and in the heaviest clay soils, and from the entire south and to the extreme north end of the state. Satisfactory results have been obtained both in our experimental plots and in a large number of commercial

orchards—in fact, I have yet to hear of any injury where the material was used in commercial peach orchards, even one year old orchards.

I understand some injury resulted from the use of Paradichlorobenzene last fall in other sections of the country, rather extensive injuries, but the conditions were entirely different from what we would ever expect to have in Indiana, and I do not believe that these experiments should deter us, in the central west, from following our present recommendations.

MR. W. E. BRITTON: I would like to inquire if this material is not covered?

MR. S. C. CHANDLER: Yes, we cover it.

MR. W. E. BRITTON: It seems to me the chief diffiiculty would be in covering it where you do not remove the weeds.

MR. S. C. CHANDLER: We have had no trouble of this kind. I picked out an orchard especially grassy and weedy, more than we expected to find in a commercial orchard, and we had no difficulty in handling the material.

MR. ALVAH PETERSON: In New Jersey, in treating about 250 nursery trees we killed 75 per cent of the trees with one-fourth ounce per tree. On two year old trees in some orchards, we have found considerable injury. However, there are many growers in the state of New Jersey who are at the present time using one-fourth ounce per tree on trees one year old, and three-eighths to half an ounce on two year old trees.

During 1923 we also saw injury in an 8 year old orchard, which we believe was due to paradichlorobenzene. This orchard was weakened at one time by frost injury, and it was also severely infested. The grower, for the first time, last fall (1922) treated that orchard with paradichlorobenzene, and 25 per cent of the trees were dead at the first of September of this year (1923).

MR. F. H. LATHROP: I was wondering whether any one has done any work with the actual concentration of the gas. Even if a two year old, or a one year old tree is given, say one-quarter of an ounce of the material, the actual concentration in the gas may be much greater than one ounce on a tree four to six inches in diameter, so we are really giving it a heavier dose of the material—that is, considering it on the basis of the concentration of the gas. I was wondering whether any work has been done along the line of determining the concentration of the gas that the trees can stand?

MR. S. C. CHANDLER: I do not think any work has been done along that line.

MR. J. J. DAVIS: I would like to ask Mr. Peterson the season he got injury to nursery stock?

MR. ALVAH PETERSON: We carried out experiments for two years. Some applications were put on in May, and other applications were put on in September, and we ran experiments all the way from four days up to indefinite exposures.

MR. S. C. CHANDLER: May I ask the type of soil?

MR. ALVAH PETERSON: This happened to be a heavy, Penn loam soil, and in another nursery it was a sandy loam soil.

VICE-PRESIDENT S. B. FRACKER: The next paper is by O. I. Snapp.

THREE YEARS OF PARADICHLOROBENZENE EXPERIMENTS IN THE SOUTH

BY OLIVER I. SNAPP, *Entomologist, U. S. Bureau of Entomology, Fort Valley, Ga.*

ABSTRACT

Paradichlorobenzene treatment of peach trees for control of the peach borer, *Aegeria exitiosa* Say, has become an annual practice in the program of orchard management in Georgia. Five hundred thousand pounds of the material were used in the Southeast during the 1923 season. The results of experiments indicate that under normal conditions the large doses exposed for short periods are not as effective as the smaller doses exposed for four to six weeks. No tree injury resulted from the use of the various doses around three, four and five year old peach trees in Georgia during 1921 and 1922 when normal weather conditions prevailed. However, during the 1923 season a precipitation deficiency occurred accompanied by abnormally high temperatures. These unusual weather conditions caused rapid action from the gas, and as a result some rather severe injury has shown up on three year old trees from the use of the ¾ and one ounce dose. During each of the three years no injury has resulted from the use of the ¾ ounce dose around four and five year old trees for twenty eight days. One and two year old trees have shown, each year, more or less injury from the use of the ½ and ¾ ounce dose. To date no injury has been revealed from allowing the mounds to remain around the trees over winter. Late October and November applications of paradichlorobenzene gave a control of around seventy-five per cent. December applications were worthless. Applications made around April 1st in Georgia gave about seventy per cent control. Laboratory experiments show that the gas is liberated at about the same rate in both sandy loam and clay soils. Tests in the laboratory have repeatedly shown that the higher the moisture content of the soil and the lower the temperature, the slower is the action of the gason the borer.

The use of paradichlorobenzene in the South for control of the peach borer (*Aegeria exitiosa* Say) has rapidly increased in popularity during the last three years. A large percentage of the peach growers in Georgia have now adopted the treatment, and the use of the chemical in that state has become an annual practice in the program of orchard manage-

ment. During the 1921 season a quarter of a million pounds of paradichlorobenzene were used for borer control by the peach growers in the Southeastern States. During the following season (1922) about the same amount was used. Reports, however, show that during the fall of 1923, five hundred thousand pounds of the material were used in the Southeast. These figures are indicative of the increased interest in this new method of borer control, and of the satisfactory results that have been obtained from its utilization in commercial peach orchards.

Blakeslee's work prior to 1920 showed that the chemical could be safely used on trees six years of age and older for the control of the peach borer. In certain cases, however, he noticed injury to trees younger than six years of age that were treated with paradichlorobenzene. In view of the fact that the peach borer is often very destructive in young orchards, and since it would be highly desirable, if possible to use the chemical on peach trees of all ages, extensive experiments have been conducted in Georgia by the Bureau of Entomology during the last three years to ascertain whether the new method of borer control could be extended to trees of all ages under climatic conditions in that latitude. For these experiments peach trees ranging from one to five years of age were used. Studies were also made of the effect on the trees from not opening up the mounds and removing unspent crystals six weeks after the application. The effectiveness of late fall, early winter, and spring applications of paradichlorobenzene were tested in another series of experiments. The laboratory work included a study of the effect of temperature and moisture on the rate of evaporation of paradichlorobenzene and what influence these factors have on the mortality of the peach borer from the toxic gas.

No attempt will be made in this paper to give detailed accounts of the results obtained from any of the work. An effort will be made to merely point out the most important things revealed as a result of the work, and to report on the action of the chemical during a season when a precipitation deficiency is accompanied by abnormally high temperatures. (I wish to give due credit to Mr. C. H. Alden of the U. S. Bureau of Entomology who has assisted the writer with all of the paradichlorobenzene work in Georgia during the last three years.)

Results from the Use of Paradichlorobenzene on Young Peach Trees

During the past three years several thousand peach trees ranging from one to five years of age have been treated with both small doses of

paradichlorobenzene for long exposures and large doses for short exposures. For the long exposure tests one-half, three-fourths and one ounce doses were allowed to remain around the trees for periods of three, four and six weeks, and also over winter. For the short exposure tests, one and a half, two, and two and a half ounce doses were exposed to the trees for periods of four, eight and twelve days.

The results of these experiments indicate that under normal conditions the large doses exposed for short periods are not as effective as the smaller doses exposed for four to six weeks. The three-fourths ounce dose as well as the one ounce dose gave almost perfect control of the borer when exposed to young peach trees for four weeks. In nearly every case the control was one hundred per cent. The control from the one-half ounce dose averaged about 87.5 per cent. The control from large doses exposed for four, eight or twelve days varied between fifty-five and ninety per cent.

Three separate examinations for tree injury from the various treatments were made on all the trees. The first was made about six weeks after the application, the second during the following spring, and the final one during mid-summer of the following year. No injury resulted from the use of the various doses around three, four and five year old trees during 1921 and 1922 when normal weather conditions prevailed in Georgia. However, during the fall of 1923 very abnormal weather conditions occurred in central Georgia, causing rapid action from the paradichlorobenzene crystals and an unusual resultant effect on young peach trees, which should be of special interest to those engaged in paradichlorobenzene investigations elsewhere.

Paradichlorobenzene is placed around peach trees in Central Georgia between October 10 and 15. During the month of September 1923 a precipitation deficiency occurred which caused the soil to be exceedingly dry when the material was put out in October. During the three weeks following the application, practically no rainfall occurred. A local weather station six miles from where the paradichlorobenzene experiments were conducted reported only a trace of rainfall for the entire month of October 1923, which was the smallest amount recorded for any October at that point during the last 32 years. The normal October precipitation in Central Georgia is about three inches. Therefore, a drought occurred before the paradichlorobenzene was applied in 1923, and continued for three weeks following the application.

The soil temperature during October 1923 was abnormally high in Central Georgia. The mean soil temperature from sun rise to sun set

during the three weeks in October following the paradichlorobenzene application was 70.5°. The mean soil temperature for the same period in 1922 was 64.9°, and for the same period in 1921 was 63.2°. Soil temperatures were not taken in Central Georgia prior to 1921, but by comparing the October 1921, 1922 and 1923 mean sun rise to sun set soil temperatures with the mean air temperatures for the same period and then with the mean air temperatures for October during the last 32 years, the normal mean sun rise to sun set soil temperature for October was found to be about 65°. Therefore, the mean soil temperature during October 1923 in Central Georgia was at least 5 degrees above normal.

Moisture and temperature greatly influence the rate of evaporation of paradichlorobenzene crystals. The dryer the soil and the higher the soil temperature the more rapid is the generation of paradichlorobenzene gas from the crystals. Little, if any, gas is given off when the soil temperature is below 60° F. A study of the October 1923 climatological data for Central Georgia to which I have referred above, revealed the fact that the weather conditions were very unusual, and were favorable for an exceedingly rapid generation of paradichlorobenzene gas.

Upon examining the young peach tree four weeks after the application for borer mortality and tree injury, the crystals had entirely disappeared in most cases, which was unusual, and the condition of the dead larvae caused us to conclude that the rapidity of the action from paradichlorobenzene had been so great during the fall of 1923 that borer mortality resulted within two weeks.

The rapid action from the gas last October brought about by the unusual weather conditions, caused more or less injury to young peach trees. Rather severe injury resulted to some of the three year old trees from the use of the ¾ and one ounce dose. The extent of this injury cannot be definitely determined until next spring or summer, however, at the present time some severe cambium injury has been discerned. During the three years that the experiments have been under way (including 1923) no injury has resulted from the use of the ¾ ounce dose around four and five year old peach trees for twenty eight days. Under the weather conditions in Central Georgia during October 1923 the one ounce dose caused some flecking of the bark layers of four and five year old trees, and in a few cases the six weeks exposure of the one ounce dose caused some cambium injury to trees of those ages.

One and two year old trees have shown, during each of the three

years, more or less flecking of the bark layers or cambium injury from the use of the ½ and ¾ ounce dose.

Effects from Allowing Paradichlorobenzene to Remain Around the Trees All Winter

Each year a hundred, or more, trees five years of age, or older, were treated with one ounce doses of paradichlorobenzene in the fall and the mounds left up around the trees over winter to note the effects from allowing the crystals to remain around the older trees all winter.

Examination of these trees made during the spring and again in July of 1922 and 1923 showed no tree or trunk injury from allowing the mounds to remain around the trees over winter. Some injury may be revealed during the spring or summer of 1924 from allowing the mounds to remain around the trees in Georgia during the present winter, on account of the abnormal weather conditions that occurred there last fall.

Results from Late Fall, Early Winter, and Spring Applications

The effectiveness of late fall, early winter, and spring applications of paradichlorobenzene was tested on trees five years of age, or older, in another series of experiments. A different group of trees was treated with the one ounce dose every other week from the middle of October until the middle of December, and examinations for effectiveness made during the following May. To determine the effectiveness of the spring applications a number of trees was treated with the one ounce dose about April 1st and examined for borer control during the middle of May.

These experiments showed that the applications made during the latter part of October and during November in Georgia gave a control of around seventy-five per cent. December applications in Georgia were worthless as no borer mortality resulted from the applications placed during that month on account of the low soil temperature. Paradichlorobenzene applied to trees in the spring around April 1st in Georgia resulted in about a seventy per cent control.

Paradichlorobenzene for peach borer control gives the best results when used at the close of the oviposition period of the adult. Life history studied of the peach borer in Middle Georgia show that maximum emergence of adult moths takes place in middle September and the last of them are on wing during the latter part of that month. Allowing five days for the oviposition period of the last females, and a maximum

of ten days for the incubation period at that time of the year, paradichlorobenzene applied between October 10–15 in Middle Georgia finds all larvae hatched, and since they are small and in shallow galleries a control of from ninety-eight to one hundred per cent results provided the material is applied strictly according to directions. For best results in the Northern or Southern part of the State the dates should vary about five days from those found to be most satisfactory for the Central Section.

Late October and November treatments may give fair results. However, if the late fall should happen to be abnormally cold very poor control would result. An effort should be made to apply the material shortly after the oviposition period of the insect, so that sufficient action from the crystals may be had before the soil temperature becomes too cold for the proper generation of the gas.

Spring applications are not as effective as the early fall applications on account of the size of the larvae in the spring and the fact that many individuals are in deep galleries by that time. The larger the borers and the deeper they are in the galleries, the more difficult it is to kill them with paradichlorobenzene gas. Spring applications cannot take the place of the early fall treatments, and should only be used where for an unavoidable reason the grower was not able to apply the material in the fall. Aside from poorer results with spring applications they permit the borers to work in the trees unmolested until many are nearly full grown.

Experiments with Paradichlorobenzene at Room Temperatures

Many experiments were conducted in the laboratory during the three years that the field experiments have been under way, including studies on the rate of evaporation of paradichlorobenzene under ordinary room conditions, mortality of peach borer larvae exposed to paradichlorobenzene, and the influence of temperature and moisture on the effectiveness of the material.

The rate of evaporation around peach trees in an orchard is much faster than it would be at room temperature—the latter temperature being lower. From ninety-one to one hundred and thirty-five days were required for the evaporation of one-half ounce doses of paradichlorobenzene in the laboratory imbedded from four to six inches below the soil surface. One-half ounce doses placed on the soil surface evaporated in sixteen days. Therefore, the soil mounded on top of the crystals around peach trees to prevent surface washing and to serve as a con-

tainer for the gas should not be deep, as the deeper the crystals from the top of the soil the slower will be the generation of the gas.

Laboratory experiments continually show that the gas is liberated at about the same rate in both sandy and loam clay soils. Under ordinary room conditions paradichlorobenzene gas killed all larvae as far down as one foot below the soil level within a period of three weeks. Tests in the laboratory have also repeatedly shown that the higher the moisture content of the soil and the lower the temperature, the slower is the action of the gas on the borer. A detailed account of the results obtained from the first year's work with paradichlorobenzene in Georgia will be found in Department Bulletin 1169, which was recently issued as a report of progress.

VICE-PRESIDENT S. B. FRACKER: The next paper is by T. L. Guyton.

ORIENTAL FRUIT MOTH IN PENNSYLVANIA IN 1923

BY T. L. GUYTON, *Pennsylvania Department of Agriculture, Harrisburg*

During the season of 1923 the Oriental Fruit Moth (*Laspeyresia molesta* Busck) caused a heavy loss to fruit growers in the southeastern corner of Pennsylvania. Reports show the insect to have been present before 1923, but not numerous enough to cause commercial loss.

In 1921 the Bureau of Plant Industry made a survey of two of the counties now heavily infested, and in none of the several peach orchards examined was the presence of the moth suspected. One report in 1922 showed the moth to have been established at one point. No doubt the moth was present in many other places, but no out-standing damage was noted.

In 1923 estimated losses varied thruout the area of infestation. One peach grower reports a loss of seventy-five percent of his crop, or about twenty carloads. His was the heaviest loss reported. Nearly all other reports gave about twenty percent as the loss. Quince fruits found in the infested area were entirely destroyed. This fruit is a favorite food of the larvae.

Only a fragment of the life history of the moth was observed. A definite brood of adults was evident the last week of August. These moths produced the brood of larvae which caused the heavy loss to Elberta peaches. It was difficult to find larvae about peach trees on October first, but quinces contained many larvae, and several larvae were found in cocoons about the quince trees. Active larvae were found in fallen quinces as late as November fifth.

The exact area of infestation in Pennsylvania is not definitely known. It is evident that the shipment of ripe peaches from infested areas has done much this year to extend the range of the pest. It is known to be present only in the southeastern quarter of the state at this time.

VICE-PRESIDENT S. B. FRACKER: The next paper is by Mr. W. P. Flint.

A NEW APPLE PEST, METACHROMA INTERRUPTUM

BY W. P. FLINT, *Urbana, Ill.*

Occasionally we encounter some native insect that is acquiring a taste for cultivated crops in preference to its natural food. This appears to be the case of the feeding on apple and peach by the willow beetle, *Metachroma interruptum* Lec.

During the summer of 1921, several lots of apples were sent to the Experiment Station at Urbana showing a type of injury different from that known to be caused by any of the insects which commonly feed on this fruit in Illinois. In 1922, apples showing this same type of injury were received from nearly all the orchard sections of the State and a few orchardists reported 5 to 10% of the fruit in their orchards had been damaged.

A search of these orchards during the day in an attempt to find the insect causing this injury was unsuccessful. An examination at night however ,showed hundreds of small brown beetles crawling about over the foliage and feeding on the fruit. The beetles were first found during the last week of June but had been feeding before this. They had all disappeared by July 4, 1922. The insect was identified by Doctor C. P. Alexander and W. S. Blatchley as *Metachroma interruptum*, family Chrysomelidae. It is supposed to be a western species feeding on the willow and to occur but rarely in Illinois and Indiana. Correspondence with the entomologists in the group of states lying west of the Mississippi has shown that *Metachroma interruptum* is fairly common in South Dakota and Kansas, but there are no records of its feeding on fruits.

In 1923, an attempt was made by Mr. J. H. Bigger of the State Natural History Survey to work out the life history of the insect. Owing to pressing calls for assistance in chinch-bug control, this work was not completed. A few additional facts were gathered concerning the habits of the adult beetles. The spring this season was cool and most of the common insects did not appear as early as usual. Metachroma was not found feeding on the apples until the last week in June

and continued up to about July 20. Beetles were found mating each night, examinations were made during this period. The beetles fly to the apple trees just as it is becoming dark and it was impossible to trace their flight. They remained on the trees at least until midnight. Usually one or two would be found on a fruit, sometimes as many as six. No feeding was noted on the foliage of the trees in the orchard, but the beetles fed on the leaves of apple when confined in cages. Careful search during the day of the soil and usual insect hiding places in the vicinity of the orchard disclosed one beetle under the bark of a tree and one in the leaf mulch under the trees.

Cage experiments showed the beetles were not killed by the strengths of arsenate of lead used for control of codling moth, that is, one pound to fifty gallons of water, and were repelled by this poison, but would feed on the sprayed foliage after twenty-four hours when no other food was offered. Three and four pounds of lead to fifty gallons of water killed the beetles in cages after about forty-eight hours.

Extent and Character of Injuries

The injury by this insect, so far as noted, is caused entirely by the feeding of the beetles on the surface of the fruit. Even a small amount of feeding rendering the fruit unfit for first grade and in most cases reduces it to cider stock.

During 1921, the injury was slight, in 1922, the crop in some orchards was damaged 2 to 10%, in 1923, the damage was less varying from scattered feeding on single apples to 5% injured fruit in at least one orchard. Even in 1923, damage on individual trees would run to 75% of the fruit. Injury to apples was also reported by J. J. Davis and Doctor Bennet A. Porter from points in south western Indiana.

During 1923, the characteristic injury by this beetle was noticed on the peaches in several orchards in the southern part of the State and in one peach orchard the damage was severe on the outer rows.

Mr. Arthur Gibson: I would like to ask about the occurrence of this insect.

Mr. W. P. Flint: The insect is common in Indiana and Illinois. It has also been found in Kansas and Nebraska. It is apparently not common west of the Mississippi river.

Mr. E. P. Felt: It may interest those present to know that in New York State in recent years we have had very similar injuries on apples,

although not nearly so severe, by a closely related species, *Nodonota puncticollis* Say.

VICE-PRESIDENT S. B. FRACKER: The next paper is by S. W. Frost and E. M. Craighead.

DUSTING FOR LEAF-HOPPERS (*EMPOA ROSAE* L.) IN BEARING APPLE ORCHARDS

By S. W. FROST, and E. M. CRAIGHEAD

ABSTRACT

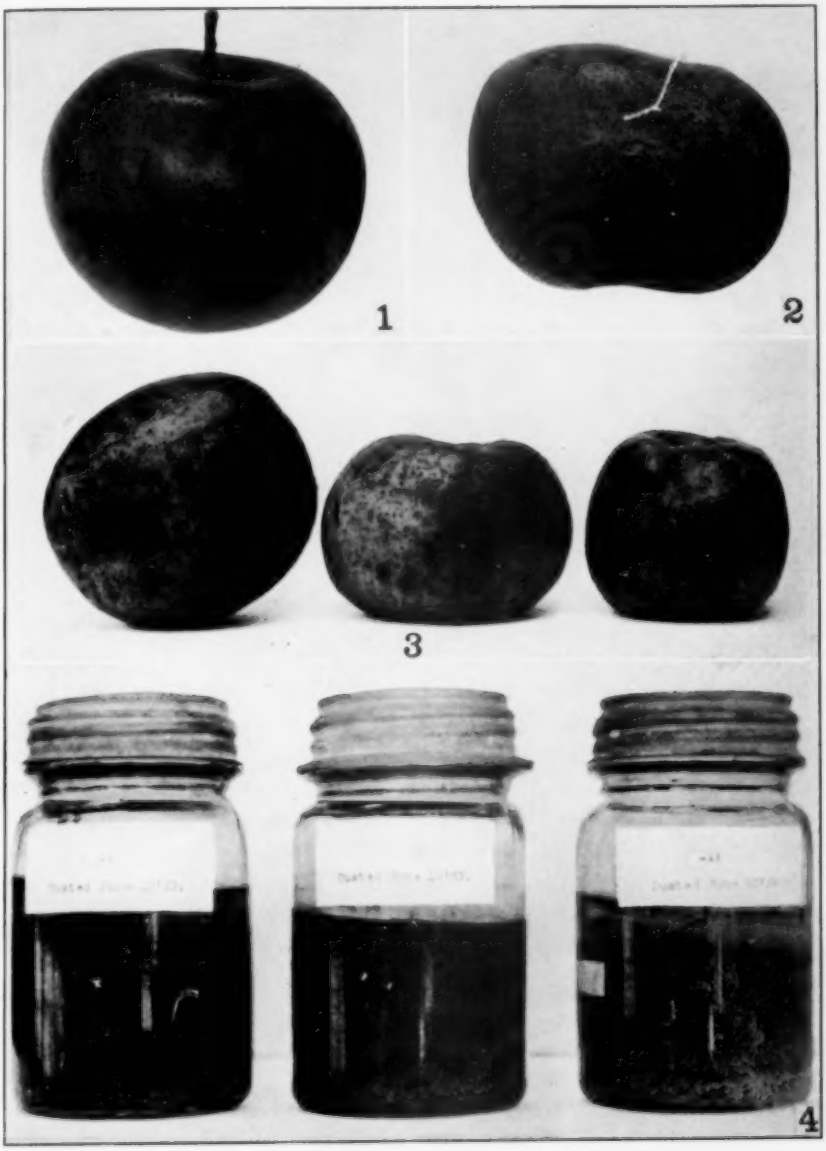
This paper open a new field in entomology, that of controlling leaf-hoppers (*Empoa rosae* L.), in bearing orchards. The seriousness of the pest and a new type of the injury is described. Field tests show that the nymphs and adults can readily be killed by nicotine dusts.

The leaf-hoppers (*Empoa rosae* L.) have become a serious pest on bearing apple trees throughout Pennsylvania. During the past five years they have increased gradually in numbers and now, without doubt, can be classed among the most serious insect pests of the apple. During the summer of 1923 they were exceedingly abundant in well-cared-for orchards where no nicotine dust or spray was used during the summer. Their abundance demanded some immediate attention.

Heretofore the necessity for special applications of spray or dust to control leaf-hoppers on bearing apple trees, has not appeared to be very urgent during normal seasons. Due to the fact that little or no data have been secured upon the practical value of spraying or dusting in bearing orchards, the writers have deemed it expedient to try some dusting experiments. This really opens a new field in economic entomology.

NATURE OF THE INJURY

The most serious injury is, no doubt, inflicted upon the foliage, although serious damage is sometimes done to the fruit. The leaf-hoppers suck the sap from the leaves, removing the chlorophyll and causing them to turn white in color. The leaf-hoppers suck out the contents of whole cells while the red-spiders puncture individual cells, removing only part of their contents. This accounts for the difference in appearance of two similar kinds of injury. Leaf-hopper injury, together with red-spider and scab injury often render the foliage almost functionless. Premature dropping of the foliage and the fruit takes place as the result of such injuries. No doubt a material reduction in the size of the fruit results in case of serious injury of this kind. No data, however, have been secured to indicate this.



1, Fruit spotted by liquid discharge from nymph; 2, 3, leaf-hopper scars on York imperial; 4, Pint jars showing leaf-hopper population from three different trees. These leaf hoppers were brought down by nicotine dusts.

During the summer of 1923, many orchardists suffered serious losses through the spotting of the fruit by the liquid discharged by the hoppers. The spotting was so abundant in some orchards as to seriously mar the quality of the fruit. Rains during the latter part of the summer washed these spots forming sooty streaks and ruining the appearance of a large percentage of the fruit.

A new and serious type of injury was also noted on the fruit. The nymphs puncture the fruit with their beaks. Later in the season these punctures crack open giving the fruit a mottled or russeted appearance. This type of injury was particularly noticeable on york imperial, stayman winesap, grimes golden and pound apples. On the stayman the scars were usually triangular in shape probably having their origin in the lenticles. On the yorks the scars were rod shaped often resembling a fruit injured by rubbing against a limb.

Control Measures

During the past season, some preliminary control measures were taken. Nicotine dusts were applied during the month of June with encouraging results. The dusting was done on the twelfth and fourteenth of June. This was a trifle too late as nearly one third of the nymphs had transformed to adults. A dust two weeks earlier would have yielded better results. The afternoon was selected for the work. At that time the air was warm and dry and there was little wind. It was found necessary to select ideal conditions for the dusting work. Under these conditions a high percentage of control was affected. When the air currents were strong it was found impossible to maintain an atmosphere of nicotine dust about the tree long enough to give satisfactory results. The work was done with one of the latest types of dusting machines. Two types of dust were used; a 2% nicotine sulphate dust with hydrated lime as a carrier and free nicotine dusts with clay as a carrier. The percentage of both nymphs and adults killed by the nicotine dusts ran exceedingly high.

In making the test, counts were made of the numbers of leaf-hoppers per leaf before and after dusting. These counts were taken from the inside as well as the outside of the tree and from the lower as well as the upper surface of the leaves. The first counts were made in the morning, the dusting was done shortly after noon and the second leaf-hopper counts were made a few hours after dusting.

Immediately after dusting a tree, the leaf-hoppers commenced to fall to the ground. In badly infested orchards they sounded like rain as

they fell upon the lower leaves of the tree. Heavy white muslin sheets were placed under the trees to catch the hoppers as they fell. They were so numerous that it was difficult to make counts. A few counts were made of the number of leaf-hoppers per square foot from which the number upon the sheet was estimated. They were so abundant that they could be measured by the pint. An average twelve year old tree with a medium infestation yielded about a half a pint of leaf-hoppers. Older trees yielded over a quart of leaf-hoppers

SUMMARY OF LEAF HOPPER COUNTS IN DUSTED PLATS, ARENDTSVILLE, Pa., 1923

Material	No. leaves examined	No. leaves free from L. hoppers	% free leaves	No. leaf-hoppers	No. leaf hoppers per leaf
		BEFORE DUSTING			
2% Nic. Sulphate, H. Lime	430	89	20.6	1219	2.8
1¼% Free Nicotine Dolomite	567	185	30.8	1035	1.8
2% Free Nicotine Dolomite	436	115	26.3	998	2.2
2% Free Nicotine Dolomite	654	198	30.2	913	1.3
2% Nic. Sulphate H. Lime	656	261	38.8	700	1.0
		AFTER DUSTING			
2% Nic. Sulphate, H. Lime	498	413	82.8	150	.30
1¼% Free Nicotine Dolomite	1266	1232	97.3	34	.02
2% Free Nicotine Dolomite	1227	1175	95.6	65	.05
2% Free Nicotine Dolomite	1485	1210	81.5	406	.26
2% Nic. Sulphate H. Lime	1749	1495	85.4	175	.10

Applications made on June 12th.

CONCLUSION

While we cannot say that dusting or spraying for leaf-hoppers in bearing orchards will be practical, because of the great abundance of these insects and the possibility of the orchard becoming reinfested from adjoining orchards, the great abundance of leaf-hoppers in Pennsylvania and their seriousness as a pest on apple, demands considerable attention. Nicotine dusts have given an excellent percentage of kill under favorable conditions. It still remains to be discovered whether one or two applications of nicotine dust during June will be sufficient to keep the hoppers under control. The cost of nicotine dust or spray would prohibit a larger number of applications.

VICE-PRESIDENT S. B. FRACKER: We will now listen to a paper by H. A. Gossard.

SHOULD THE MIDSUMMER APPLE SPRAY BE TIMED FOR THE SECOND BROOD ONLY OF CODLING WORM?

By H. A. Gossard

Abstract

Studies of the life history of the codling moth, *Carpocapsa pomonella*, haye been made, partially or fairly eomplete, at Marietta in southern Ohio, at Wooster in the north central section and at Gypsum in the northwestern section. Records of the dates when the sprays are commonly applied have also been kept through a series of years. The stages of development of the moth at the dates of spraying are shown by the life history chart. The tentative conclusion is reached that when the season is late the summer spray should be earlier than usual instead of later and that a later second summer spray is desirable in such a year.

It is quite generally assumed by orchardists and entomologists that the July spray given to apples in Ohio and nearby states should be specially timed for the second brood of worms and if timed to work most havoc with this brood, it is likewise assumed that the results will be more acceptable than if the spray is given earlier or later than this pivotal date.

After a good many attempts to render this spray most effective by timing it according to data secured by rearing the moths in cages and from field observations, moth traps on the tree trunks, egg-laying records, etc., we raise the question if the best date can be determined by this method; or if we must supplement such data by experience data and settle upon a time that has given maximum results through a long period of years. Results are so frequently disappointing from the spray after all possible care has been taken to put it on after the moths have commenced to emerge and just when egg-laying has commenced, that it seems worth while to discover why a spray, so timed, sometimes gives a much more wormy harvest than sprays put on neighboring orchards at an earlier time, chosen on the basis of average experience.

Studying the life-history of *Carpocapsa pomonella* in relation to the dates when the midsummer spray is commonly applied in Ohio, as shown by records extending over several years, it appears that the explanation may lie in the overlapping of the broods of codling worm. As shown by the life-history chart the eggs of the spring brood are still hatching when the moths of the second brood commence to emerge and there is from 1 to 3 weeks overlapping of the larvae of the spring and summer broods. This overlapping comes in the month of July, six weeks or more after the last treatment for codling worm is given, following bloom, if the usual schedule is followed. If given a week earlier

than usual, the midsummer spray will effectively dispose of the first-brood worms then hatching, but may not be sufficiently lasting to kill all the worms of the summer brood, the late comers of which will be hatching 6 to 8 weeks later. If delayed till the second-brood eggs are hatching, all the late comers of the first-brood escape, and the grower has been obliged to do a good job of guessing just when to spray, or else he has had to spray sufficiently early to insure the destruction of the first-brood worms and to use adhesive sprays so copiously that the poison is carried on the fruit and leaves until well into September.

At Marietta, summer-brood moths begin to emerge in late June and egg-laying commences in some years about the 4th of July, but usually does not reach the climax till early in August. The midsummer spraying should, therefore, be done the first week in July or thereabouts in that locality, though in some seasons the moths do not appear numerously until after July 15. Experience suggests an earlier spray to give best control, and the dates used for spraying in Washington County vary from July 1 to July 15. The only possible explanation for this necessity is that a spray is needed at this time to destroy the late comers of first-brood worms, and that the poison will adhere long enough to kill the bulk of the summer-brood worms, even though most of them do not hatch until sometime in August. The midsummer spray is not so apt to be washed from the leaves and fruit by rains as the earlier sprays and, therefore, lasts over a longer period. There is, too, an accumulation of poison on the trees from the earlier treatments, making the poison cover thicker than it was immediately following the spring applications.

The midsummer spray is given at Wooster from July 20 to August 1. Observation of the results leads us to the conclusion that in the average season, July 20 is best. That the blooming was late is not a good cause for postponing the spray, but on the contrary seems to be a good reason for applying the spray early. In such a season the midsummer brood is not delayed so much as the spring brood, and in mid-July, the latter part of the spring brood is more damaging than usual. A supplementary spray the first week in August may be very desirable in such a year, but if this is not applied, apparently the rule should be, "Apply the midsummer spray early and very thoroughly if the season has been backward."

The progress made in this study has been stated in considerable detail in the Monthly Bulletin, Ohio Agricultural Experiment Station for May–June, 1923, pp. 73–78.

VICE-PRESIDENT S. B. FRACKER: A paper will now be presented by Mr. P. J. Parrott.

SOME SIDE LIGHTS ON SPRAY INJURIES TO APPLE FRUITS AND FOLIAGE

By P. J. PARROTT, *Geneva, N. Y.*

ABSTRACT

Because of the danger of injury to apple foliage and fruits from lime-sulfur, experiments were undertaken to determine the value of hydrated lime, calcium caseinate and glue in reducing the injurious properties of this spray as well as to ascertain the utility of various sulfur and copper dusts and sprays as possible substitutes for lime-sulfur for summer applications. This report considers only the effect of the different materials on the foliage and fruit of apples. All the spray and dust mixtures affected to some degree the surfaces of apple fruits. "Sun scald" or "spray burn" was the most conspicuous type of injury and was common in all of the plats receiving applications of sulfur either as lime-sulfur solution or flowers of sulfur, or sulfur flour applied as a dust. Russeting varied in intensity with the different treatments. Injuries to foliage were largely confined to plats sprayed with lime-sulfur solution. The addition of calcium caseinate, glue, and lime hydrate reduced to some extent injuries to both fruits and foliage, but they did not prevent important injury to foliage in some instances.

During recent years much interest has been aroused relative to the action of spray and dust mixtures on the quality of fruit as well as on the productive capacity of orchard trees. Advocates of dusting have pointed out that, generally speaking, dust preparations are more safe to foliage and fruit than certain common spray mixtures.

In spite of the fact that much can be said in favor of lime-sulfur for the treatment of both apples and pears for certain applications, it is generally recognized that this spray may injure foliage and, so far, there is very little definite information relative to the conditions that favor important damage, or regarding means of controlling its injurious properties and thus render it more safe.

Injuries by lime-sulfur vary greatly in kind as well as in degree. A very common form of injury is browning or "burning" of the tips and margins of the leaves. This may involve large areas of the leaves of a considerable proportion of the foliage and is frequently attended with premature defoliation of varying extent. In spraying trees for pear psylla this type of injury may be severe, and it is a question if in the long run applications do not cause more damage than the pest which prompted the treatment. Even tho the leaves may reveal no serious discoloration, apple trees sprayed repeatedly during the growing season may show very characteristic differences from unsprayed trees or trees

treated with wettable sulfur, bordeaux mixture or dust mixtures, as revealed by the number, contour and color of the leaves. Likewise, the fruits may be affected ,exhibiting russeted netting and blotches or dark, discolored, circular areas known as "sun scald," "spray burn," etc.

Bordeaux mixture also displays limitations since it may produce spotting of the leaves as well as marginal injuries, while the fruits may be russeted and distorted.

Growers, generally, are familiar with the effects of these two sprays and, pending the discovery of more desirable substitutes, seem willing to take chances of injury even tho in occasional years damage of an important extent may be sustained.

In the State of New York lime-sulfur is used extensively for the treatment of fruit trees, and for certain purposes there is no material which is quite its equal. From the standpoint of foliage treatment, however, there is need of a new spray equally effective as an insecticide and fungicide or some method should be developed of handling lime-sulfur which will render it more safe to foliage. For these reasons the Geneva Experiment Station has been testing for two seasons different formulas of "wettable sulfur" or "dry mix" sprays as possible substitutes for lime-sulfur, as well as hydrated lime, calcium caseinate and glue to determine their value in reducing the injurious properties of the lime-sulfur spray. It should also be noted that little or no consideration has been given to the problem of determining the accumulative effects of different systems of treatment, so provision was made to ascertain the effects of successive treatments of lime-sulfur and other materials on the productiveness of trees over a period of years.

In the experiments herein described, the spray materials were used at standard strengths, namely, lime-sulfur solution for foliage applications at the rate of 2.5 gal., to 100 gals., of water, and powdered lead arsenate 3 lbs., to 100 gals. Except as indicated, the formula for the "wettable sulfur" or "dry mix" spray was 4 lbs., lime hydrate, 8 lbs., sulfur, 1.5 lbs., powdered lead arsenate and 50 gals. water. Glue and calcium caseinate were used as spreaders at the rate of 4 ozs., glue or 1 lb., calcium caseinate to 100 gals. unless different amounts are indicated. The apple trees under treatment belonged to the variety Greening and were 25 years old. The spray mixtures were applied at the rate of 10 gals., per tree and 5 applications, which includes the delayed dormant treatment, were made during the season, as provided in the standard spraying schedule. The dust mixtures were used as stated in Table 1.

The more important data relative to injuries to fruit and foliage

TABLE 1. RELATION OF DUST AND SPRAY APPLICATIONS TO "SPRAY BURN" AND RUSSETING OF APPLES

Number of plat	Treatment	Number of trees examined	Average number of apples per tree	Av. no.of spray burn apples per tree	Percentage of spray burn apples	Condition of apples with respect to russeting	
1	Spray (lime-sulfur with calcium caseinate)	9	1547	17.0	1.10	light	*
2	Spray (lime-sulfur)	9	1724	21.0	1.23	moderate	†
3	Spray (lime-sulfur with glue)	6	1217	8.0	0.68	moderate	†
4	Spray (sublimed sulfur 8 lbs.)	10	1416	5.0	0.33	light	*
5	Spray (sublimed sulfur 8 lbs. and lime hydrate 8 lbs.)	9	2265	0.5	0.01	light	*
6	Spray (flour sulfur 16 lbs.)	9	2388	8.4	0.35	light	*
7	Spray (flour sulfur 16 lbs., lime hydrate 8 lbs.)	10	1651	4.4	0.26	light	*
8	Spray (flour sulfur 8 lbs.)	7	3486	6.6	0.18	light	*
9	Spray (flour sulfur 8 lbs., lime hydrate 8 lbs.)	9	1895	2.2	0.11	light	*
10	Dust (90–10 sulfur 5 lbs. per tree) regular schedule	9	1143	6.1	0.53	trace	°
11	Dust (90–10 sulfur 2 lbs. per tree) weekly	10	1468	15.8	1.07	trace	°
12	Dust (85–15 sulfur 5 lbs. per tree) regular schedule	8	1287	12.1	0.94	trace	°
13	Dust (85–15 sulfur 2 lbs. per tree) weekly	7	1957	11.0	0.56	trace	°
14	Dust (77–13–10 lime-copper, 4 lbs. per tree) regular schedule	10	1846	0.0	0.0	severe	‡
15	Dust (77–13–10 lime-copper, 4 lbs. per tree) weekly	6	1871	0.0	0.0	severe	‡
16	Dust (77–13–10 lime-copper, 2 lbs. per tree) regular schedule	7	1177	0.0	0.0	severe	‡
17	Dust (77–13–10 lime-copper, 2 lbs. per tree) weekly	9	1302	0.0	0.0	severe	‡
18	Dust (copper arsenite 4 lbs. per tree) regular schedule	10	1127	0.0	0.0	severe	‡
19	Check, no treatment	5	849	0.0	0.0	none	
20	Dust (copper-arsenite-lime 2 lbs. per tree) regular schedule	8	1303	0.0	0.0	severe	‡
21	Dust (copper-arsenite-lime 2 lbs. per tree) weekly	7	1681	0.0	0.0	severe	‡
22	Dust (copper carbonate, 4 lbs. per tree) regular schedule	4	2225	0.0	0.0	severe	‡
23	Spray (copper carbonate, 4 lbs. per 100 gals.) reg. schedule	4	1789	0.0	0.0	severe	‡

°Trace. Barely discernible, not commercially important.

*Light. Noticeable, not commercially important.

†Moderate. Sufficiently important with a goodly percentage of the apples as to raise question of the proper grade of fruit.

‡Severe. Russeting so severe with varying percentages of the apples as to cause rejection from Grade A.

obtained in the experiments during 1923 are briefly summarized as follows:

Effect of Spray and Dust Mixtures on Fruits

All the spray and dust mixtures affected to some degree the surfaces of apple fruits. The most conspicuous type of injury was "sun scald" or "spray burn" characterized by the occurrence of somewhat circular brownish or brownish-black spots on the sides of the apples. These were most conspicuous on the south side of the tree where there was apparently the greatest exposure to sunshine, and were common in all of the plants receiving applications of sulfur either as lime-sulfur solution or flowers of sulfur or sulfur flour applied as a dust. (See Table 1). This type of injury was most abundant in the plats sprayed with lime-sulfur solution. In considering the number of apples affected with "spray burn" in relation to the total yield, it will be observed that the amount of injured fruit is not large, but, small as it is, it must be admitted that the size and color of the blemished areas are such as to produce in the mind of the one examining the trees that the damage is much greater than the actual counts indicate. Associated with "spray burn" there was russeting of the fruits, which was also noticeable in all the plats receiving applications of sulfur, both spray and dust. Judging from the number of apples affected and the effect of the discoloration on the general appearance of the yield, russeting was really more important than spray burn.

Russeting varied in intensity with the different treatments. In certain plats a small percentage of the apples were distinctly russeted so that the natural green color of the fruits over more or less extensive areas was largely or completely obscured. With the majority of the apples the discoloration appeared as streaks or netting in varying gradations. Even tho barely discernible, and therefore not conspicuous enough to be considered important, it is an interesting fact that a small amount of injury detracts from the appearance of the apples, as they lack to some extent the finish and luster of normal fruits.

In the plats sprayed with lime-sulfur russeting of apples was general, involving perhaps 80 or 90 percent of the fruits. It was especially noticeable about the calyx end, altho it was by no means confined to this region. The addition of calcium caseinate to lime-sulfur (1 lb. to 100 gals.), caused an appreciable reduction in the number of affected apples as well as in the severity of russeting, while 2 lbs., of the spreader to the

same volume of spray seemed to produce improved conditions in these respects. On the other hand, russeting was fully as conspicuous on the trees sprayed with lime-sulfur containing glue as those treated with lime-sulfur alone.

The "wettable sulfur" sprays produced a very noticeable amount of russeting, altho it was less than that caused by lime-sulfur. There was no apparent difference in the action of sublimed flowers of sulfur or flour sulfur, but russeting seemed to be somewhat more conspicuous wherever lime was used.

Sulfur applied as a dust caused some russeting that was unquestionably due to the treatment. This was very much less than that occurring in the lime-sulfur plats, and was even less conspicuous than that in the "wettable sulfur" plats. From the standpoint of the finish and luster of the fruits, the apples dusted with sulfur or sprayed with "wettable sulfur" were superior to those sprayed with lime-sulfur and were unexcelled by the product from any of the other treated plats.

The copper dusts used in all the treatments provided in the spray schedule, including the calyx application, caused more severe and more general russeting than any of the materials applied, occasional fruits being greatly distorted and revealing cracks which sometimes extended as far as the core. In general, the damage was more conspicuous in the plats which received a heavy dosage of 4 lbs., per tree, the copper arsenite dust being more injurious than the dehydrated copper dust. The so-called "spray scald" was entirely absent from the plats receiving applications of the copper mixtures.

Influence of Dust and Spray Mixtures on Foliage

The only plats treated with sulfur preparations that displayed injuries were those sprayed with lime-sulfur solution and these consisted largely of browning or burning of the tips and margins of the leaves. It was difficult to form any definite conclusions relative to the influence of either calcium caseinate or glue in reducing the damage. Lime hydrate was superior to either of these materials, and while its addition to lime-sulfur did apparently make this spray more safe, it by no means wholly prevented damage. The plats dusted with sulfur or sprayed with "wettable sulfur" showed no evidence of injury and during the entire season were readily distinguishable by the luster of the leaves from those sprayed with lime-sulfur. The foliage of the latter was dull colored.

Copper carbonate applied as a spray caused severe injuries, as indi-

cated by the development of brown spots in the leaves and browning of the margins. Subsequently a large proportion of the foliage dropped. The same material applied as a dust produced quite similar results, altho the injury was not so extensive.

Dehydrated copper sulfate and copper arsenite dusts exerted, on the whole, no injurious effects; at least not to any important degree, altho all the trees receiving heavy applications of copper dusts displayed characteristic brown spots which were diagnosed by various workers as frog eye (*Sphaeropsis malorum*). As these were observed only in the plats treated with the copper dusts, it is difficult to draw any other conclusion than that the spotting was primarily due to the treatment.

Conclusions

The standardization of apple grades and the growing discrimination against imperfect fruits in commercial packages have directed attention to the importance of spray injuries, revealing a need of safer spraying mixtures as well as improved methods of handling standard insecticides and fungicides to reduce danger of injury to fruit and foliage.

Of common spraying mixtures, none are quite as satisfactory as lime-sulfur for the treatment of apples. The chief defect of this spray is that it may cause burning of leaves as well as "spray burn" and russeting of the apples, injuries which vary in degree apparently with different sorts of apple and according to seasonal conditions. No methods have been devised by which these injuries may be entirely prevented or largely controlled. The addition of calcium caseinate caused an appreciable reduction in the amount of "spray burn" and russeting, but still both types of injury were conspicuous. Glue, apparently, was not as effective as calcium caseinate. Lime hydrate reduced burning of foliage to an appreciable extent, but did not prevent important damage in some instances. Since calcium caseinate as revealed by analyses[1] prevents any important reaction between lime-sulfur and lead arsenate and lime hydrate neutralizes the soluble arsenic developing from this combination, it would appear that sulfur is largely responsible for the damage to apple foliage and fruit and that sulfur contained in sulfides is more injurious than ground sulfur or sublimed flowers of sulfur applied as dusts or in suspensions.

Sulfur suspensions, known as "wettable sulfur" or "dry mix" sprays, were tested as possible substituted for lime-sulfur. They produced noticeable russeting as well as "spray burn" of apples, but the damage

[1]Unpublished analyses by Dr. R. W. Thatcher and L. R. Streeter.

was less than that of lime-sulfur. No difference was observed in the action of sublimed flowers of sulfur or flour sulfur. The addition of lime seemed to aggravate the injury. These sprays differed markedly from lime-sulfur in that they caused no injury to the foliage.

Sulfur applied as a dust produced both russeting and "spray burn" but both were very much less in evidence than in the plats sprayed with lime-sulfur. The general appearance of the fruit was superior to that treated with "wettable sulfur" or lime-sulfur.

The copper dusts caused no spray burn. Heavy applications produced severe russeting which was accompanied by cracking of the surfaces of the apples. The apples from trees receiving light dosages lacked the luster of fruits dusted with sulfur or sprayed with "wettable sulfur "

In the treatment of apples with dusts the danger of injury to fruit and foliage is not as great as with spraying mixtures. The undesirability of applying copper mixtures in the calyx application, which had long been recognized, seems to be corroborated by these tests. From the standpoint of pest control, as well as safety to plants, much is to be said in favor of frequent applications of light dosages of the different dusts as against heavy dosages at wider intervals.

The data from this series of experiments suggest no satisfactory spray as a substitute for lime-sulfur, altho the "wettable sulfur" mixtures should be given further trial. Likewise little light has been shed relative to methods of controlling injury by lime-sulfur. Under the circumstances all the grower can do is to follow the usual instructions such as, apply minimum amount of spray necessary to wet foliage; avoid coarse, drenching sprays; treat trees systematically according to schedule to combat both insects and diseases and thus prevent rupturing of foliage which facilitates spray injuries; add lead arsenate to lime-sulfur when ready to spray, and do not allow mixture to stand long before applying; employ calcium caseinate or lime hydrate to prevent or neutralize respectively, free arsenic formed by the reaction between lime-sulfur and lead arsenate; abstain from spraying during periods of high temperatures, etc.

Some varieties, such as Greenings, McIntosh and Ben Davis, have proved more susceptible to burning of foliage than other sorts; and Greening apples especially have generally been less free of spray scald and russeting than Rome apples, the injuries of different types varying considerably according to seasonal conditions and character of spraying

operations. With the former varieties it is sometimes a difficult problem, especially when scab is active, to spray the trees thoroly and not cause a certain amount of injury. However, more attention to such details on the part of the grower can hardly fail to be of considerable benefit.

The addition of calcium caseinate to lime-sulfur tended to more even distribution of the spray, and apparently reduced to some extent both "spray burns" and russeting. Its actual value for these purposes as well as its influence on the insecticidal efficiency of standard insecticides should receive further consideration.

MR. WILLIAM MOORE: I would like to ask what time of day the spraying was done.

MR. P. J. PARROTT: The dusting was all done in the morning.

MR. WILLIAM MOORE: You didn't notice any different burning from lime sulphur in the middle of the day?

MR. P. J. PARROTT: No.

VICE-PRESIDENT S. B. FRACKER: The next paper is by L. A. Stearns and W. S. Hough.

SPREADER TESTS ON APPLES AND PEACHES: A SECOND REPORT

By L. A. STEARNS and W. S. HOUGH, *Virginia State Crop Pest Commission*

ABSTRACT AND CONCLUSIONS

The efficacy of a casein spreader (Kayso) in the commonly recommended sprays for apple and peach has been studied for the second season. These sprays, with and without the spreader, were mixed by the writers and applied by the regular orchard force.

The second season's results parallel those of the first year's work. There is no indication that the incorporation of the spreader with the usual sprays influenced the protection of the fruit from insects and diseases. The conclusion is that the use of a casein spreader (Kayso) in the apple and peach sprays under orchard conditions in Virginia is not justified from the standpoints of effectiveness and economy.

In 1922, an investigation was commenced by the writers with the thought that since it had been shown under laboratory conditions that certain materials appear to influence the spreading and adherence of sprays it was equally desirable to demonstrate their effectiveness and economy in orchard practice. The spreader tests on apples and peaches discussed herein are a continuation of this study on which a preliminary

report has already been made[1]. This season, the tests were confined to casein (Kayso) with the object of determining its value as a spreader and adhesive not only in the summer sprays but in all applications of the scheduled programs for apple and peach.

Tests on Apples

Tests were conducted by the senior author in Mr. L. Clark Hoge's Ophir Orchard at Leesburg. The experimental section of this orchard was a 14-year old planting of the Grimes Golden, Gano and Rome Beauty varieties. At Winchester, tests were conducted by the junior author in the Stayman-Winesap orchard of the Shenandoah Vinegar Company. These trees, varying in age from 8 to 15 years, are subjected annually to a severe infestation of codling moth due to their proximity to large apple bins where cull apples are stored prior to being ground for cider.

The Virginia spray calendar for apples, in 1923, called for a delayed dormant spray of nicotine sulphate, 1–800, and winter strength lime-sulfur; sprays of powdered lead arsenate, 1 pound to 50 gallons, and summer strength lime-sulfur to be applied when the cluster buds are pink, when the petals are falling and two weeks after petal-fall; Bordeaux mixture, the 4–5–50 formula, and powdered lead arsenate, 1 pound to 50 gallons, to be applied four weeks and ten weeks after petal-fall.

At Leesburg, each variety received all applications as scheduled with and without the spreader, the spreader being used at the recommended rate of 1½ pounds to 200 gallons. At Winchester, on the other hand, Scalecide, 1–15, was substituted in the delayed dormant spray, and all other sprays were applied as scheduled with and without the spreader, the spreader being used at the increased rates of 2 and 3 pounds to 200 gallons.

In each orchard, the spray outfit was a 200 gallon Hardy. Both rods and guns were used, with a pressure varying from 225 to 300 pounds. One lead was operated from the tower and the other on the ground. The spray materials were mixed by the writers, and the applications made by the regular orchard force under their supervision.

At picking time, each variety was graded separately, and the results tabulated by plots. For convenience, the data for the three varieties at Leesburg are summarized in Table 1. The results at Winchester are given in Table 2.

[1]Jour. Econ. Entom., Vol. 16, No. 2, pages 198–201, April, 1923.

TABLE 1. RESULTS OF TESTS WITH CASEIN SPREADER ON APPLES, GRIMES GOLDEN, GANO AND ROME BEAUTY VARIETIES, LEESBURG, VIRGINIA, 1923

Type of Injury	Plot 1, 13,527 Apples Regular Treatment No Spreader		Plot 2, 15,601 Apples Regular Treatment With Casein Spreader 1–1½–200	
	No.	Percent	No.	Percent
Codling Moth				
Oriental Moth	131	.97	163	1.04
Leaf Roller				
Bud Moth	163	1.20	206	1.32
Curculio	276	2.04	363	2.33
Aphis	354	2.62	827	5.30
[1]Warting Scars	1075	7.95	952	6.10
Scab	689	5.09	583	3.74
Cedar Rust	75	.55	79	.51
Black Rot				
Bitter Rot	36	.27	38	.24
Spray Burn	528	3.90	612	3.92
Plot Averages		2.73		2.72

TABLE 2. RESULTS OF TESTS WITH CASEIN SPREADER ON APPLES, STAYMAN-WINESAP VARIETY, WINCHESTER, VIRGINIA, 1923

Type of Injury	Plot 1 2,087 Apples Unsprayed		Plot 2 4,636 Apples Regular Treatment No Spreader		Plot 3 3,663 Apples Regular Treatment with Casein Spreader 2–200		Plot 4 3,570 Apples Regular Treatment With casein Spreader 3–200	
	No.	%	No.	%	No.	%	No.	%
Codling Moth	1656	79.34	1235	26.64	888	24.24	1042	29.19
Leaf Roller	18	.86	13	.28	7	.19	27	.75
Curculio	15	.71	34	.73	28	.76	18	.50
Sooty Blotch	495	23.23	102	2.20	176	4.80	44	1.23
Plot Averages		26.04		7.46		7.50		7.97

From the results in Tables 1 and 2, it is evident that the sprays without the spreader gave equally as efficient protection to the fruit as the sprays with the spreader added. In no case does the difference in the average amount of injury in the several plots exceed one percent.

It was concluded from the previous season's work that Nicotine Sulphate 40% (Black Leaf 40) and casein (Kayso), as used were uncongenial. In this connection, attention is called especially to the

[1]Miscellaneous insect injuries of a character which made immediate determinations at the time of grading doubtful were for convenience grouped under the heading, "warting scars."

relative percentages of aphis injury on the "no spreader" and "spreader" plots, as given in Table 1. It should be added, here, that this injury was consistently more severe on the "spreader" plots; doubled in the case of Grimes Golden and Gano varieties and trebled in the case of Rome Beauty variety. Apparently, casein (Kayso), when used at the recommended rate, and nicotine sulphate 40% (Black Leaf 40), when used at the usual dilution, do not occur in the spray solution in the correct proportions to react properly. It has been brought to the writers' attention that to prepare nicotine-caseinate the reaction seems to require 1 gm. of casein to 1 cc. of nicotine. Casein and nicotine sulphate, as used in the previous work and here as well, are present in the spray solution in the approximate proportions of 2 gms. of casein to 3 cc. of nicotine. It is suggested that herein may be found an explanation of the uncongeniality noted.

Tests on Peaches

The information in this particular, as in the preliminary report, is incident to the Oriental Fruit Moth project of the Crop Pest Commission. Spraying operations in the experimental control of this insect in 1923 were conducted in the American Fruit Growers Inc. Loudoun Orchard at Leesburg. This is a young Delicious apple orchard interplanted with peaches of the Carman and Belle varieties. It was in its fourth year and bearing its first crop.

The schedule of treatments in this orchard was that commonly recommended for peaches. The usual dormant application of winter strength lime-sulfur was followed by a "shucks-off" spray of powdered lead arsenate, 1 pound, and hydrated lime, 4 pounds, to 50 gallons, the same, with 8 pounds of sulfur added, being repeated three weeks later. One month before the fruit ripened, an 8–4–50 sulfur-hydrated lime spray was applied.

In this experiment, four of the test plots in which both varieties were represented gave results pertinent to the effectiveness of casein. Test or plot 1 received the regular treatment without the spreader; plot 2, the casein spreader in all applications; plot 3, nicotine sulphate 40% in the summer applications; plot 4, nicotine sulphate 40% in the summer applications and casein in all applications. Nicotine sulphate 40% (Black Leaf 40) was used at the 1–800 dilution and casein (Kayso) at the recommended rate of 1½ pounds to 200 gallons of the spray solution.

The spray outfit used was a 200 gallon Bean equipped with two two-nozzle rods. It was operated at a pressure varying from 250 to 275

pounds. Both leads were handled from the ground. The spraying was done from only one side of the row, each operator encircling the trees in his row as the outfit moved across the orchard. The spray materials were mixed by the senior author and the applications made by the regular orchard force under his supervision.

When the peaches were picked, they were graded and the results tabulated by varieties. As in the case of apples, the variety variations were so slight that the results have been combined in Table 3.

It will be noted by reference to Table 3 that the results are in complete accord with those secured in the tests on apples. Again, in no case does the difference in the average amount of injury in the several plots which received or failed to receive the spreader, exceed one percent. Furthermore, these results parallel exactly those reported for peaches in 1922.

TABLE 3. RESULTS OF TESTS WITH CASEIN SPREADER ON PEACHES, CARMAN AND BELLE VARIETIES, LEESBURG, VIRGINIA, 1923

Type of Injury	Plot 1 41,079 Peaches Regular Treatment No Spreader		Plot 2 66,938 Peaches Regular Treatment with Casein Spreader		Plot 3 89,460 Peaches Regular Treatment with Nicotine Sulphate 40%		Plot 4 52,285 Peaches Regular Treatment With Nicotine Sulphate 40% and Casein Spreader	
	No.	%	No.	%	No.	%	No.	%
Curculio	3974	9.674	6347	9.481	9432	10.543	4683	8.956
Brown Rot	29	.070	37	.055	75	.083	36	.068
Scab	143	.348	159	.237	380	.424	216	.413
Spray Burn	2024	4.927	1221	1.824	1444	1.614	934	1.786
Plot Averages		3.755		2.899		3.166		2.806

MR. F. A. FENTON: I would like to ask if chemical tests were made of the leaves sprayed with casein to determine the amount of arsenic or lead oxide present.

MR. L. A. STEARNS: No such tests were made.

MR. F. A. FENTON: This year in Iowa we have been conducting some experiments for controlling the apple maggot. One hundred leaves were picked from one hundred different trees that had been treated with casein and we found twice as much lead oxide after a period of 18 days on fruit that had been sprayed with casein than on fruit where casein had not been used.

MR. WILLIAM MOORE: Did I understand that you sprayed with nicotine sulphate and casein?

MR. L. A. STEARNS: No.

MR. H. A. GOSSARD: We have noted in Ohio at least 2 or 3 cases in which casein was used with the spray and more burning resulted than where it was omitted.

MR. LAWSON CAESAR: I have seen serious burning from using casein with lime sulfur and arsenate of lead. In some cases the burning was so severe at the end of the spraying season that I would not care to use casein again because of this injury.

VICE-PRESIDENT S. B. FRACKER: The next paper is by Mr. F. Z. Hartzell.

THE ESTIMATION OF DOSAGE FOR VOLATILE DUSTS: AN ILLUSTRATION OF THE VALUE OF CORRELATION MATHEMATICS TO ENTOMOLOGY

By F. Z. HARTZELL, *Vineyard Laboratory, Fredonia, N. Y.*

ABSTRACT

The term volatile dust is proposed for materials which kill insects by the evolution of toxic gases. It is suggested that dosage with such preparations be defined as the number of cubic feet of *tree volume* and *tree space* occupied by one pound of dust. Experiments with volatile dusts for the control of pear psylla, in western New York, have indicated that, for this insect, on the basis of tree volume, one pound of dust should not occupy a space of more than 1500 cubic feet, and, on the basis of tree space, the maximum volume should be 1900 cubic feet. Correlation and partial correlation calculations were used to study the relation of efficiency to dosage, temperature, and percentage of *open space*. Dosage was found to exert the greatest influence. The effect of temperature was not as marked as laboratory studies indicate and this was, doubtless, due to the increased convection currents and decreased humidity that usually accompany rise in temperature under field conditions.

The expression "contact dust" is ambiguous because it includes substances which kill, more or less, by direct contact and those that destroy insect life by evolving toxic gases. The term "volatile dust" is proposed for the latter class.

The advent of volatile dusts has introduced problems that do not arise in the use of ordinary contact or arsenical dusts, chief of which is the envelopment of the plant with a dose of gas lethal to the pest. They are problems of open air fumigation. Successful fumigation depends upon the density of the gas and the time during which it is allowed to act, the former being based upon the amount of materials used per

cubic foot. The writer proposes to place the dosage of volatile dusts upon the same basis. Briefly, dosage is the number of cubic feet of *tree volume* or *tree space* occupied by one pound of dust.

Definitions

By *tree volume* (T_v) is meant the cubic contents of an imaginary right cylinder having a diameter (D), which is the mean diameter, and a height (H) the same as that of the tree under investigation, all measurements being in feet and tenths. Mean diameter is the average of two diameters of the tree taken at right angles to each other. In mathematical symbols, $T_v = 0.785\ D^2H$. Dividing this product by the number of pounds of dust used on the same tree $\left(\frac{T_v}{P}\right)$ gives the number of cubic feet occupied by one pound of dust on the basis of tree volume. Since pear trees vary in shape and habit and because, when enveloped, the cloud does not conform closely to the contour of the tree, a cylinder represents the space as well as a more complicated solid and, in addition, the volume is easily computed.

Tree Space (T_s) is the product of the planting distances and the height; for example, a tree 16 feet high, planted 20 x 18 feet would have a tree space of 5,760 cubic feet. This result divided by the amount of dust used on the tree $\left(\frac{T_s}{P}\right)$ gives the number of cubic feet occupied by one pound of dust, on the basis of tree space. The difference between tree space and tree volume is designated *open space* (S_o).

$$\text{Percentage of open space} = 100\frac{S_o}{T_s}.$$

Nature of Experiments and Data

During pear psylla experiments in western New York, 1921–23 inclusive, a total of 15, 802 trees (86 acres) were dusted in cooperative field trials. These tests included dusts of varying nicotine content but the majority were 2 per cent lime-nicotine mixtures. Owing to cost, a number of growers used less material per tree than recommended, with the result that some failures occurred but it gave an excellent opportunity to determine the effect of dosage.

The greatest difficulty, from a biometrical point of view, was the limited number of trees upon which data could be secured, owing to

the amount of time required for counting the thousands of dead psylla and for re-dusting the "count" trees to determine the survivors of the original application. This gave the data from which to calculate the percentage efficiency of the operation. In addition, generally, the following data were secured on each count tree: size and shape (the latter by means of photographs), planting distances, amount of dust applied, and temperature. A total of 46 trees, treated with 2 per cent lime-nicotine dust of practically the same toxicity, had simultaneous measurements of the following variables: (1) Per cent efficiency of the operation; (2) dosage, (3) temperature, and (4) percentage of open space. Some of the statistical constants, calculated from the data, are given in Table 1.

TABLE 1. MEANS, STANDARD DEVIATIONS, COEFFICIENTS OF VARIABILITY, AND RANGE OF VARIABLES IN PEAR PSYLLA EXPERIMENTS

Variable	Mean	Standard Deviation	Coefficient of variability	Range
Percentage of efficiency of operation	72.78± 1.69	17.03± 1.20	23.40±2.45	32.8—99.0
Dosage on basis of tree volume (cu. ft.)	2931.22±122.67	1233.46± 86.74	42.08±4.87	1218—5359
Dosage on basis of tree space (cu. ft.)	4529.78±266.78	2682.51±188.63	59.22±5.91	1688—11000
Temperature Fahr.	71.44± 0.69	6.93± 0.49	9.70±0.97	61—84
Percentage of open space	28.59± 1.70	17.07± 1.20	59.71±5.96	0—60.4

CORRELATION

The first three problems presented are the following: (1) effect of dosage on efficiency, (2) the influence of temperature on efficiency, (3) the relation of open space to control. The simplest method of measuring the effect of one variable upon another is to determine the correlation coefficient (r), the variables involved being indicated by subscripts. These are known as zero order coefficients and mean that the relation between two variables has been measured without regarding the influence of other variables. The mathematics of correlation will not be presented because they are explained in detail in a number of elementary texts on statistics. The subscripts denoting the several variables in the investigation are as follows:

subscript 1 indicates the percentage efficiency of the operation,

subscript 2, the dosage on the basis of tree volume $\left(\frac{T_v}{P}\right)$

subscript 3, the temperature.

subscript 4, the percentage of open space $\left(100\ \frac{S_o}{T_s}\right)$,

subscript 5, the dosage on the basis of tree space $\left(\frac{T_s}{P}\right)$.

For example, r_{12} is the correlation coefficient between percentage of efficiency and dosage $\left(\frac{T_v}{P}\right)$, when the temperatrue and open space is allowed to vary. The value of these zero order coefficients are given in Table 2.

TABLE 2. CORRELATION COEFFICIENTS OF VARIABLES INVOLVED IN PEAR PSYLLA EXPERIMENTS

Zero Order Coefficients	First Order Coefficients	Second Order Coefficients
r_{12} —.502 ± .074	$r_{12\cdot3}$ —.467 ± .078	$r_{12\cdot34}$ —.464 ± .078
r_{13} —.246 ± .093	$r_{14\cdot4}$ —.486 ± .076	$r_{13\cdot24}$ +.150 ± .097
r_{14} —.188 ± .096	$r_{13\cdot2}$ +.137 ± .098	$r_{14\cdot23}$ —.138 ± .091
r_{15} —.411 ± .083	$r_{13\cdot4}$ —.220 ± .095	
r_{23} +.667 ± .055	$r_{14\cdot2}$ —.124 ± .098	
r_{24} +.164 ± .097	$r_{14\,3}$ —.152 ± .097	
r_{34} +.175 ± .096	$r_{23\cdot4}$ +.657 ± .057	
	$r_{24\cdot3}$ +.065 ± .099	
	$r_{34\cdot2}$ +.089 ± .099	

It will be noted that these values seem to indicate that the most important factor involved in the successful application of volatile dust is the dosage (r_{12} and r_{15}). Another important result should also be noted: viz, a negative correlation between efficiency and temperature (r_{13}) which would mean that, within the range of temperature involved in the experiments—61 to 84 degrees, Fahr.—increase in temperature decreased the control. This is contrary to the results of laboratory experiments by other workers who claim that the correlation is positive. The examination of the data (omitted because of lack of time) reveals the fact that, in most instances the heavier dosages were applied when the temperature was low and the correlation coefficient r_{23} confirms this, indicating that the effect of temperature is masked by the influence of dosage. This point will be discussed subsequently under partial corre-

lation. The relation between efficiency and open space seems also to be slight.

Partial or Net Correlation

In an ideal experiment, two factors are allowed to vary while all other influences are held as nearly constant as possible. Such investigations are practically impossible in the field. What is needed is a measure of the relationship between two variables when the other variables are held constant. This measure is provided by partial or net correlation coefficients. The notation needs explaining. Partial correlation coefficient subscripts have a decimal form. The two subscripts to the left of the period are known as primary subscripts and indicate the variables measured, while the subscripts to the right of the point are designated secondary subscripts and show what factors are held constant. For example, $r_{14.23}$ shows that the correlation is measured between efficiency and percentage of open space, when the dosage and temperature are held constant.

The chief problem to be solved is this: what is the net correlation between the percentage of efficiency and the dosage when all the trees are considered constant as regards temperature and percentage of open space? Stated otherwise, is the difference between r_{12} and $r_{12.34}$ significant? Another question which demands an answer is; what is the effect of temperature on efficiency when dosage and open space is kept constant? The values of the first and second order coefficients are set forth in Table 2.

It will be noted that the difference between r_{12} and $r_{12.34}$ is $.038 \pm .108$, which is not significant since the probable error is greater than the difference between the two coefficients. The objection may be raised that the number of observations is small (46). Suppose that there were 414 observations and assume that the coefficients remain the same, all the probable errors would be only one-third those shown in Table 2. The difference between r_{12} and $r_{12.34}$ would then be $.038 \pm .036$ and would still lack significance. In other words, the variation due to temperature and open space have not, apparently, affected the relation between efficiency and dosage. The same might be said of the relation between efficiency and open space ($r_{14.23}$). It is vastly different as regards the effect of temperature on efficiency when dosage and open space is held constant. for $r_{13.24}$ is positive. The difference between r_{13} and $r_{13.24}$ is $.396 \pm .134$, which is almost significant notwithstanding the paucity

of numbers. This substantiates the work of Rudolf[1]. The reason the coefficient ($r_{13.24}$) is not larger is, perhaps, due to the fact that convection currents are greater and humidity less with rise in temperature, the former making envelopment of the tree more difficult.

This study illustrates the danger of using zero order coefficients alone in drawing conclusions and shows the necessity of measuring as many simultaneous variables as possible and investigating by means of partial correlation before drawing conclusions. In the experiments discussed, it must be concluded that the results are indicative but do not have as great an element of certainty as would have been possible with a larger number of observations. However, the method of analyzing the data rests upon a substantial foundation and one purpose of the paper is to show this need. To use partial correlation, two conditions are necessary; (1) all zero order correlation must have linear regressions, and (2) the number of observations must be large.

Determination of Dosage

The determination of dosage is now a simple matter since it has been shown that, to a certain extent at least, the influence of temperature, when above 60° Fahr., can be safely ignored in calculating dosage. In making recommendation, on the other hand, 65 degrees Fahr., should be set as a minimum for orchard operation. However, because the number of observations is rather limited, and since dosage plays so important a part in success, it is suggested that growers take account of the amount of open space, at least, until further investigation has definately proven that this is not a factor. If all the trees where the efficiency is 80 per cent or more be assumed as successes, it will be noted that there were no failures when the number of cubic feet of tree volume was 1,500 or less, and, on the basis of tree space, 1,900 cubic feet or less.

In order that a grower may determine the amount of dust to use, several average sized trees should be measured and the amount of material for each calculated on the basis of tree volume and then on the basis of tree space. The larger amount is the correct dosage for each tree. Add these together and take the average, multiplying by the number of trees in the orchard will give the amount of dust for one application. It may be of interest to note that on the basis of these studies, the requirements for 72 trees, which were the average in a number of orchards, varied from 0.86 lb., to 4.09 lbs., with a mean of 2.53 pounds per tree.

[1]Rudolfs, Willem. Nicotine Delivery from Dust Carriers. Jour. Econ. Ent., 15:421–424, 1922.

The results presented in this paper are based upon experiments for the control of pear psylla in commercial orchards in western New York and the particular dosages apply strictly to 2 per cent lime-nicotine dust for the control of the same insect in this region. How general they will hold for psylla in other regions or for other pests can be determined only by experiments. However, the methods of determining dosage are believed to be of general application for volatile dusts on different trees and for various insects.

VICE-PRESIDENT S. B. FRACKER: The next paper is by J. J. Davis.

COMPARATIVE TESTS WITH DORMANT SPRAYS FOR SAN JOSE SCALE CONTROL

BY J. J. DAVIS, *Purdue University, Lafayette, Indiana*

ABSTRACT

A record of outstanding results obtained for three years (1921–1923) with lime-sulphur and oils as dormant sprays for the control of the San Jose scale, *Aspidiotus perniciosus* Comst., Lime-sulphur did not give a sufficient kill to check the scale, which corroborated the results obtained by commercial orchardists in southern Indiana. Lime-sulphur is still an effective scale control in most sections of northern Indiana. Dry lime-uslphur was about as effective as the liquid concentrated provided it was used at one and one-half to two times the strength recommended by the manufacturers. Under conditions existing the past few years in most of southern Indiana, the oil sprays are the only ones which have given satisfactory control. These include the miscible oils, "petroleum soaps," and oil emulsions. The summer use of oil emulsion cannot be recommended to take the place of a dormant spray although under certain conditions a summer application materially assists in checking scale.[1]

The seeming increasing importance of the San Jose scale, *Aspidiotus perniciosus* Comst., and its possible seriousness a few years hence was recognized in making our first survey of the important orchard pests of Indiana in the winter of 1920–21. These conditions prompted us to begin a series of experiments in the spring of 1921 on the comparative value of the sulphur and oil sprays. The lubricating oil emulsion was included in the tests during the summer of 1922, following the apparently phenomenal results secured by Ackerman in Arkansas in the spring of that year.

[1]In a badly infested orchard at Washington, Indiana, sprayed in August 1923 with a two per cent oil emulsion, the scale was sufficiently checked to avoid much of the fruit spotting which would otherwise have resulted. A count in this orchard made February 1924 revealed 91 per cent dead scale. In part of this orchard an additional dormant application of a two per cent emulsion was made in December, 1923 and here 100 per cent of the scale were dead so far as our extensive counts revealed.

The object of the present paper is to briefly record some of the outstanding results of the tests referred to above. As our earlier observations indicated, the San Jose scale situation became acute in Indiana more than a year ago. The majority of apple orchards, at least in the southern half of the state, are infested. Many trees have been seriously injured and even entire orchards have been wiped out. Even the peach, which has heretofore been little troubled with the scale, has become badly infested in some instances. The work in Indiana was taken over by B. A. Porter, when he came to Indiana, in the spring of 1923, and he has had the opportunity to carry on extensive tests of fundamental importance. None of Porter's results are here recorded.

The three years of tests are summarized in Table 1. An explanation of points which could not be included in the tables follows:

All localities where tests were made are in the southern half of Indiana, most of them in the southwestern part of the state. All tests were on apple.

The applications in the spring of 1921 were made March 22 and 23 at Washington and March 24 and 25 at Staunton. At that time the leaf buds were opening and the leaves partly unfolded. As might be expected from applications at this late date, the miscible oil slightly injured foliage, but no permanent injury resulted. Counts of dead and live scale were made April 23–24, not less than 250 scales from representative twigs being counted in each case. The twig counts and leaf infestation made in June and September respectively gave results comparable with the counts of dead and live scale. This was true of the later experiments and no further reference is made of the twig and leaf counts in the tables. Counts of live and dead scale were made from the Staunton plots April 26. Methods used are given in more detail in our paper on "Estimating the Abundance and Damage by the San Jose Scale," to be published in the JOURNAL OF ECONOMIC ENTOMOLOGY.

In the 1921–22 experiments conducted at Bicknell and Washington, tests comparing the different types of dormant sprays were continued and were extended to include comparisons with fall and spring applications. The tests were made on heavily infested trees. At Bicknell, the fall applications were made Dec. 8, 1921, and the spring treatments March 16, 1922, while at Washington the fall tests were made Dec. 10–15, and the spring ones March 13–15. Counts of 500 scales were made the last of April. An additional 500 were counted in the Washington tests May 27–28 and the reults were practically the same as

TABLE I. SUMMARY OF RESULTS IN SAN JOSE SCALE DORMANT SPRAY EXPERIMENTS, INDIANA, 1921–23

Treatment	Time of application	Percent dead	Control
Washington, Indiana, 1921			
Miscible oil (Scalecide) 1 to 15	Spring	94.2	80
Liquid lime- sulphur (several brands) 1 to 7½	"	88.4	60
" " " " " 1 to 16 2/3	"	66.4	–0
Dry " " 12½ lbs. to 50 gals. (label strength)	"	79.1	28
" " " 18¾ " " " " 1½ x " ")	"	83.8	44
" " " 25 " " " " (2 x " ")	"	84.4	46
B. T. S. 13 " " " " (label strength)	"	75.2	14.4
" 19½ " " " " (1½ x " ")	"	80 0	31
" 26 " " " " (2 x " ")	"	91.6	71
Check—no treatment		71.0	0
Staunton, Indiana, 1921			
Miscible oil (Scalecide) 1 to 15	Spring	97.2	
Liquid lime-sulphur (several brands) 1 to 7½	"	89.2	93
Dry lime- sulphur (several brands) 12½ lbs. to 50 gals. (label strength)	"	77.2	72
" " " " " 18¾ lbs. to 50 gals. (1½ x label strength)	"	88.8	42
B. T. S. 13 lbs. to 50 gals. (label strength)	"	79.2	71
" 19½ lbs. to 50 gals. (1½ x label strength)	"	89.6	46.6
Check—no treatment	"	60.8	73.4
Washington, Indiana, 1921-22			
Miscible oil (Scalecide) 1 to 15	Fall	100	100
" " " 1 to 15	Spring	100	100
Liquid lime- sulphur (several brands) 1 to 8	Fall	85.8	53
" " " " " 1 to 8	Fall & Spring	97.6	92
" " " " " 1 to 8	Spring	94.4	81
Dry " " " " 1½ x label strength	Fall	93.4	78
" " " " " 1½ x label strength	Spring	87.9	59.6
Check—no treatment		70.0	0
Bicknell, Indiana, 1921–22			
Miscible oil (Scalecide) 1 to 15	Fall	98.4	96
" " " 1 to 15	Spring	97.6	94
Liquid lime-sulphur (several brands) 1 to 7½	Fall	78.4	44
" " " " " 1 to 7½	Fall & Sp.	90.0	74
" " " " " 1 to 7½	Spring	91.2	77
Dry " " " " 13½ lbs. to 50 gals. (label strength)	Fall	71.2	25
" " " " " 13½ lbs. to 50 gals. (Label strength)	Spring	85.0	61
" " " " " 27 lbs. to 50 gals. (2 x label strength)	Spring	92.8	81

Check—no treatment		61.6	0
Washington, Indiana, 1922–23			
Miscible oil (Scalecide) 1 to 15	Fall	100	100
Lubricating oil emulsion 2 per cent	"	98.2	97.5
Liquid lime-sulphur 1 to 7½	"	82.4	75.8
Check—no treatment		27.2	0
Bicknell, Indiana, 1922–23			
Miscible oil (Scalecide) 1 to 15	Fall	99	96.6
Miscible oil (Scalex) 1 to 15	"	100	100
Petroleum soap (Sunoco) 1 to 15	"	100	100
Lubricating oil emulsion 2 per cent	"	97.8	93.8
Liquid lime-sulphur 1 to 6	"	80	44.4
Check—no treatment		64	0
Paoli, Indiana, 1922–23			
Miscible oil (Scalecide) 1 to 15	Fall	99.3	98.8
Petroleum soap (Sunoco) 1 to 15	"	99.1	98.5
Lubricating oil emulsion 2 per cent	"	96.4	93.7
Check—no treatment		41.2	0

[1]Percentage of scale actually killed by spray, figured after the per cent dead in check had been eliminated.

[2]The results recorded here are from the best of the several dry limesulphurs tested.

earlier counts except in the case of the lime-sulphur tests which ran rather uniformly slightly higher by one to two per cent.

The 1922–23 tests were made in three localities, those at Bicknell being made Nov. 21, 1922; at Washington, Nov. 23; and at Paoli, Nov. 24. Counts were made Feb. 26, Feb. 25, and Feb. 27, respectively. From 500 to 1,000 scales were counted in each test.

The spray rod with angle disk nozzles were used where they were available and where the guns was used, special care was exercised in securing thorough applications. The 1921 applications were made by the writer; those in 1921–22 by C. R. Cleveland, J. J. Culver and the writer; those in 1922–23 by C. R. Cleveland and the writer. Most of the counts were made by C. R. Cleveland and the writer, but material assistance was secured from J. J. Culver, W. P. Flint, and B. A. Porter in making supplementary counts as a check.

RESULTS: We have concluded from these tests and many scattered observations, that the dry lime-sulphur is inefficient against the San Jose scale as it occurs at the present time in Southern Indiana when used at label strength. The liquid concentrate proved ineffective under the conditions which have prevailed in Southern Indiana the past few years. These results are corroborated by results secured where the scale could not be checked even when 1–6 strengths were used thoroughly. Even with a 90 per cent kill, the 10 per cent live scales on moder-

ately or heavily infested trees are able to increase and encrust a vigorous tree by fall. The dry lime-sulphur when used at twice label strength was about equal in effectiveness to the liquid concentrate.

The oil sprays were uniformly effective. From our tests reported above, general observations, and further tests by Porter, we would recommend a three per cent strength of the new lubricating oil emulsion where the trees are incrusted or where the scale seems to be increasing.

It might be noted in addition that rather uniformly better results were obtained by spring than by fall applications, in the case of lime-sulphur but in the case of the oil sprays, the time of application seemed to make no difference in the effectiveness of the material.

No recommendations are being made at the present time relative to the use of the new lubricating oil emulsion as a summer application. Peaches are likely to be injured. Under ordinary conditions apples in foliage are not injured and although some growers have been able to prevent scale spotting to a large extent by spraying in the summer with a two per cent emulsion, our results will not permit us to recommend the summer use of the emulsion or any other spray for the control of the San Jose scale. Because of variable results obtained by growers under conditions known to us, the emulsion cannot yet be recommended as an aphis control. Furthermore, only the *boiled* emulsion is at present recommended for scale control in Indiana.

MR. F. A. FENTON: I would like to ask Mr. Davis in what amounts the spray should be applied on apple?

MR. J. J. DAVIS: Our experience was only with the Oyster Shell Scale on lilac and similar shrubs. We have had no trouble with the Oyster Shell Scale in apple orchards which is a different form from the common one on apple, but doubtless controlled by the same measures.

MR. O. I. SNAPP: I would like to ask Mr. Davis what has been his experience, and what results he obtained from the use of the cold-stirred mixture.

MR. J. J. DAVIS: Our experience with cold-stirred mixture was not sufficient to warrant making any further statement. We have not been able to make uniform preparations in all cases with cold-stirred methods, and our results in experimental work are not sufficient to make any definite statements, except that we are not ready to recommend it.

MR. LEONARD HASEMAN: We used the cold-stirred oil emulsion in Missouri and in our experimental tests we got practically the same

results with the boiled emulsion. It is oil apparently that does the killing.

VICE-PRESIDENT S. B. FRACKER: The next paper will be by F. H. Larop and V. M. Trask.

FURTHER STUDIES OF PRUNE ROOT BORER CONTROL IN OREGON

By FRANK H. LATHROP AND VICTOR TRASK, *formerly of the Oregon Agricultural Experiment Station*

ABSTRACT

This paper is a report upon experiments conducted in Oregon during the season of 1922 in the control of the Prune Root Borer, *Sanninoidea opalescens* Edw. The treatments tested include Naphthalene Whitewash and the application of Paradichlorobenzene.

The Naphthalene Whitewash consisted of a basic formula composed of quicklime, copper sulfate, glue, and ground wood pulp, with sufficient water to form a thick paint. To this were added mixtures of naphthalene and paraffine in solid solution or naphthalene alone. The wash was applied to the tree trunks to a height of 14 to 16 inches after the soil had first been removed and the bases of the trees protected from the naphthalene fumes by means of paper collars or by a preliminary "protective" wash. In general, the treated plots showed a reduction in infestation. Best results were secured by the use of naphthalene-paraffine mixtures applied in connection with a preliminary protective wash.

Applications of one ounce of Paradichlorobenzene about the bases of the trees during the first week of September, gave excellent results when left undisturbed until the following spring. Larvae situated some distance above the soil level were not affected by the treatment. In heavy soils the action of the material was slower than in lighter soils. When this material was improperly applied or very young trees treated, severe injury resulted to prune trees.

The present paper is a report of results of applications made for the control of the prune root borer (*S. opalescens* Edw.) in the orchards of western Oregon during the summer and fall of 1922. The treatments applied include naphthalene whitewashes,[1] and paradichlorobenzene.

NAPHTHALENE WHITEWASH TREATMENTS

BASIC FORMULA. In each plot the basis of the wash was the same, but the nature and amount of the active material was varied. The basic wash was made up according to the following formula:

Quicklime	8 pounds
Copper sulfate	¼ pound
Glue	½ pound
Ground wood pulp	½ pound
Water to make a thick paint	

[1]Lathrop, F. H., and Black, A. B.: Jour. Econ. Ent., v. XIV, pp. 328–336, 1921.

The quicklime forms the body of the wash; the copper sulfate was added because of its fungicidal nature; while the glue, of course, serves as a sticker. The ground wood pulp was obtained from a paper mill, and was added to give increased body to the wash and to prevent cracking of the wash upon drying. For these purposes, the pulp served very well, but we do not regard its addition as highly important.

ACTIVE INGREDIENTS. In all of the washes applied, the active material was either naphthalene or mixtures of naphthalene and paraffine in various proportions. In making preparations of naphthalene and parraffine, the two materials were melted together over a gas flame. The naphthalene was readily soluble in the paraffine in the liquid state, and by rapidly cooling the melted material in thin layers on a glass plate, a solid solution of naphthalene and paraffine resulted. This material was ground in an ordinary food chopper to reduce it to a coarse granular form which was readily incorporated in the whitewash mixture.

The following are the combinations which were added to the basic formula:

Formula No. 1–22	Naphthalene:		1 lb.
2–22	Naphthalene: paraffine[2]	1:1	1 lb.
3–22	Naphthalene: paraffine	2:1	1½ lbs.
4–22	Naphthalene: paraffine	3:1	21 oz.
5–22	Naphthalene: paraffine	2:1	1 lb.
6–22	Naphthalene: paraffine	3:1	1 lb.
7–22	Naphthalene: "Parowax"[3]	3:1	1 lb.

METHODS OF APPLICATION OF NAPHTHALENE WHITEWASH. In nearly all cases the soil was removed from the bases of the trees to the depth of four to six inches before the wash was applied. The base of the trunk was then fitted with a paper collar or painted with a protective wash[4] to eliminate the injurious effects of the naphthalene fumes below the soil level.

After the paper collar was in place or the "protective wash" had dried the naphthalene wash was applied to the crown and trunk of the tree to a height of 14 to 16 inches. The soil was replaced about the base of the tree.

[2]Paraffine used was a commercial grade obtained from the Standard Oil Company. Melting point about 48° C.

[3]Trade name for a refined grade of paraffine prepared and sold by the Standard Oil Company.

[4]The "protective wash" consisted of the following ingredients:

Quicklime	4 lbs.
Copper sulfate	2 oz.
Glue	4 oz.
Powdered charcoal	1 lb.
Water to form a thick paint	

TABLE I. RESULTS OF THE NAPHTHALENE WHITEWASH TREATMENTS, COTTAGE FARM, SALEM, OREGON, 1922

Applications made June 21. Results noted December 1.

Treatments		Results					
Formula	Method of Application	Number of trees	Number of trees eated	Trees wormed Number	Infested Per cent.	Worms Total	Number of Worms Per tree
1.22 Naphthalene	Paper collar	14	8	3	37	4	.50
1.2 '	Protective wash	14	8	2	25	4	.50
1.22	Soil not removed. Cotton band at base	14	8	3	37	12	1.50
2.22 Naphthalene: Paraffine 1:1 2 lbs.	Paper collar	14	8	2	25	3	.37
2.22	Protective wash	15	8	0	0	0	0
3.22 Naphthalene Paraffine 2:1 1½ lbs.	Paper collar	14	7	2	28	4	.57
4.22 Naphthalene: Paraffine 3:1 21 oz.	do	14	7	2	28	3	.43
4.22	Pro ective was'	15	8	2	25	2	.25
4.22	So'l not removed Cotton band	15	8	5	62	10	1.25
5.22 Naphthalene: Paraffine 2:1 1 lb.	Protecti v was	15	8	2	25	2	25
6.22 Naphthalene: Paraffine 3:1 1 lb.	do	14		2	2	2	25
7.2 ' Naphthal ne: Parowax 3:1 1 lb	Paper collar	15	8		37	4	50
Checks —no treatment			34	2	4		.00

Results as shown in table 1 indicate a general reduction of infestation in the treated plots as compared with the checks. The best results were obtained with formula 2–22 used in connection with a protective wash at the bases of the trees. In the plots where the soil was not removed from about the trees, and the wash was applied over a cotton batting band placed around the trunk at the soil level, the results were unsatisfactory. The paper collars reduced the efficacy of the washes slightly, the treatments being more effective when used with a protective wash at the base of the tree. The mixtures of naphthalene and paraffine proved more effective than the napthalene alone.

No injury to the trees was detected where the washes were applied in connection with paper collars or the protective wash.

PARADICHLOROBENZENE

Paradichlorobenzene was applied to prune trees at Creswell, Corvallis, and Salem. The applications of this material were made according

TABLE II. PARADICHLOROBENZENE TREATMENTS, 1922

One ounce of material applied per tree in each case

TREATMENT				RESULTS					
Locality	Date of application	No. of trees treated	Date results noted	No. of trees wormed	Trees infested with live worms		Number of worms		
					Number	per cent	Alive	Dead	Alive per tree
Kiger Orchard, Corvallis	Aug. 19	14	Sept. 16	7	1	14	1[1]	15	.14
Skyline Orchard, Salem	Sept. 1	45	Sept. 13	15	4	26	4[2]	10	.26
do	do		do	Nov. 5	15	2	13	2	13	.13
do	do		do	Mar. 21	15	0	0	0	2	0
Woodward Orchard, Creswell	Sept. 6	45	Nov. 25	22	6	27	8	3	.36
do	Checks		do	5	4	80	8	0	1.60
do	Sept. 6	45	Mar. 23	22	0	0	0	3	0
do	Checks		do	8	3	38	3	0	.38

Small numerals indicate the numbers of larvae found on the trunk above the mounded soil.

to the methods used by eastern workers. The soil was leveled about the trees, and one ounce of the crystals was placed in a circle about two inches from the base of the tree. Soil was then mounded over the material and firmly packed. The dates of application and results of the treatments are indicated in table II.

TIME FACTOR. To be effective, it is necessary that sufficient time shall elapse after the application to permit of the volatilization of the crystals and diffusion of the gas about the base of the tree. It was found that when the results were noted in the fall, the number of living larvae varied inversely to the length of time that had elapsed since the application of the treatment. In no case were any living larvae found where the application was left undisturbed until the following spring.

POSITION OF LARVAE. Larvae situated on the trunk of the tree above the level of the mounted soil are not affected by the paradichlorobenzene treatment. In some orchards of western Oregon this constitutes a distinct disadvantage in the paradichlorobenzene treatment. Young larvae in superficial tunnels below the soil level are the first to succumb to the fumes. Large larvae in deep tunnels are more resistant, but larvae situated in deep tunnels as far as six inches below the level of the application were eventually killed. Larvae above the level of the application but below the level of the mounded soil were also killed.

INFLUENCE OF SOIL TYPE. It was found that the type of soil had considerable influence upon the action of the material. Most of the orchards of western Oregon are on heavy soils, varying from silt loam to heavy "gumbo." It was found that on the heavier soils, volatilization and consequently the lethal effects of the paradichlorobenzene were much less rapid than on the lighter soils. In the Skyline Orchard this was especially well illustrated. Where the material was applied in clay loam, approximately one-half of the crystals remained at the end of twelve days; while in a lighter silt loam in the same orchard the crystals had almost entirely disappeared at the end of the twelve day interval. So far as we have observed, none of the material has remained in crystalline form throughout the winter. However, in examining trees which had received a fall application, a faint trace of the characteristic odor could sometimes be detected in the spring.

INJURY TO PRUNE TREE. In no case was injury observed where one ounce of paradichlorobenzene was properly applied to healthy, mature prune trees, even though the material was allowed to remain undisturbed throughout the winter.

In some cases the treatment apparently hastened the death of trees weakened by infections of crown rot or root rot fungi.

Where excessive amounts of the material were used or where the material was placed in direct contact with the bark of the tree, severe injury resulted.

Applications of one-half ounce made to one and two-year-old prune trees resulted in the death of the trees in some instances, and we consider the application dangerous to trees of this age.

VICE-PRESIDENT S. B. FRACKER: The next paper is by D. M. DeLong and A. A. Mathewson.

THE HOUGHTON GOOSEBERRY APHIS (*MYZUS HOUGHTONENSIS*) AS A PEST IN OHIO

By D. M. DELONG and A. A. MATHEWSON, *Columbus, Ohio*

ABSTRACT

The Houghton Gooseberry Aphis injures gooseberries by forming leaf galls. The leaves are stunted, tightly curled and soon die. Very little fruit is produced and it is inferior in quality. The gall gives rise to a witch's broom by the formation of numerous abnormal shoots. The insect overwinters as an egg on the canes. The eggs begin hatching early in April. The first winged generation appears about the middle of May and migration takes place. They become re-established on the gooseberry and several wingless generations are found here during the summer and autumn. A second winged generation is produced in late October and the eggs are deposited a little later on gooseberry. This insect may have an alternate food plant but is able to survive normally on gooseberry alone.

Various workers in several of the eastern states have reported the Houghton Gooseberry Aphis since its description in 1909, as an insect affecting gooseberries. Very little data has been given however in regard to the degree of injury and its effects upon the plant. Also certain rather interesting and important phases of the life-cycle have not been previously reported.

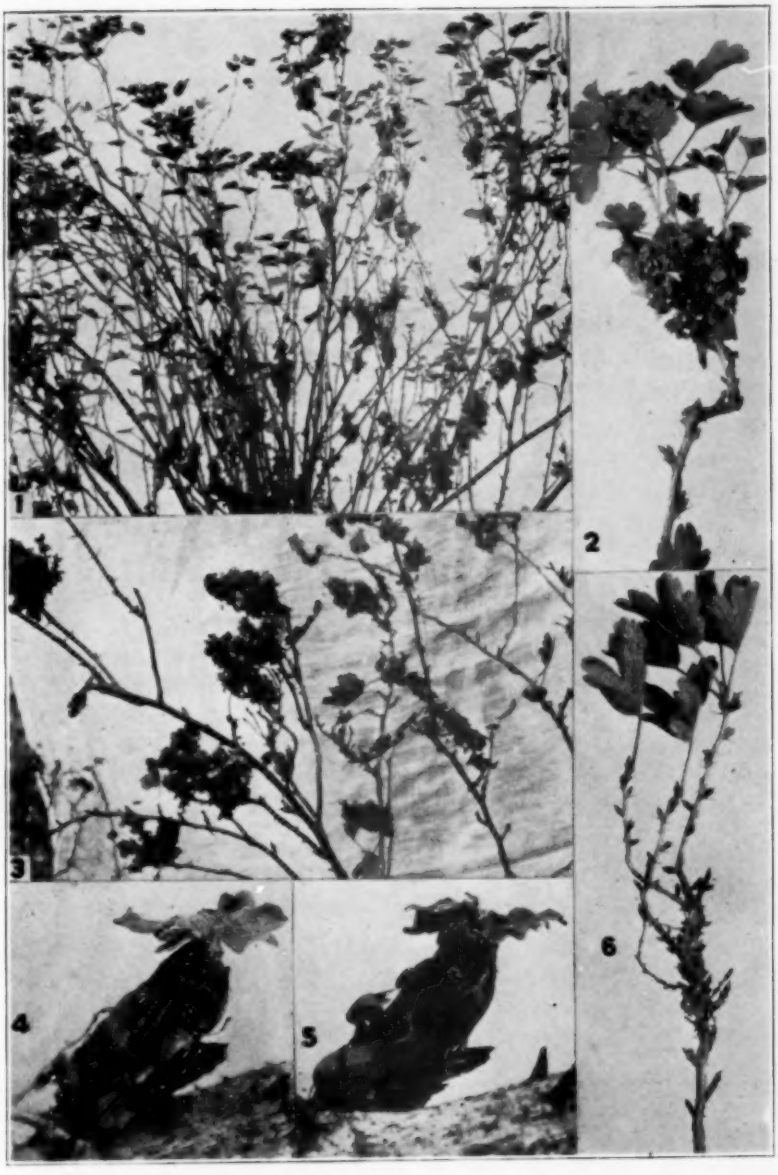
Attention was called to this problem some months ago when a grower made inquiry regarding the best control measure for this pest. His inquiry was accompanied by the statement that he owned a five acre planting of Houghton gooseberries in western Ohio which was so severely injured or destroyed by this aphid that a commercial crop of fruit could not be produced and it would be necessary to remove these canes if an adequate control measure could not be found. Upon investigation this insect was found to be causing severe injury to small as well as larger plantings and a study of its life cycle and injury were undertaken.

The injury is very conspicuous, since the insect causes the formation of a leaf gall, frequently spoken of as the witch's broom. The galls are composed of many small, stunted, tightly curled leaves and may vary in size from one-fourth of an inch to two or three inches in diameter, depending upon various conditions, chief of which are weather and abundance of individuals. The curling of the leaves is so pronounced that it is very difficult to make life cycle observations, since the insects are so completely secluded. The first seasonal galls are produced by the first nymphs hatching in the spring and each generation continues to produce new galls throughout the summer. After the formation of the galls, the leaves are soon killed, turn brown and remain on the plant for some time. The last galls formed in the autumn usually remain on the plant during the dormant season. During the development and growth of the gall this portion of the plant is apparently stimulated to produce certain definite types of growth. As has been mentioned previously, the first conspicuous change from a normal growth condition, is the formation of a large number of stunted curled leaves. The next condition following the leaf gall is the formation of the witch's broom which is caused by the gall giving rise to a large number of new shoots. Thus wherever there is a gall, a large number of unhealthy dwarfed shoots are formed which produce only a small amount of inferior fruit, instead of the normal condition of each branch producing a few healthy shoots. The vines are injured in this way very noticeably because of insufficient numbers of normal healthy canes and normal leaves, and the fruit production is decidedly reduced because of the condition of the shoots that form the fruit buds. This loss is more apparent when it is known that sixty-five or seventy galls may occur on a single plant.

Life History Notes

Many details of the life cycle cannot be given at this time, but continued observations have shown certain definite relationships with the host throughout the season.

The aphid overwinters as a shining black egg about 1 mm. long which is deposited near the ground on the lower limbs and canes. They may be placed on the bark, buds, old leaves or thorns but are usually on the lower portion of the canes. As many as ten or twelve eggs are frequently placed inside the bud scales and form the galls on the new leaves as they push out from the bud. During the past season the eggs began hatching at Columbus about April 10th when the buds were bursting, and galls were formed from the first opening leaves before they



1. A typical infested plant, showing number of galls to a single plant; 2. Appearance of a small gall; 3. Portion of a single branch with typical large galls; 4. and 5. Eggs deposited on bud. Note green leaves at tip beginning to grow; 6. Old gall with numerous shoots arising from injured portion.

had attained any size. Although the galls soon appear on all parts of the plant, they are especially abundant on the new young canes which are only a few inches above the ground. The wingless females continue to give birth to living young and form new galls until about May 17, when the winged females appear and begin migrating. This migratory period continues for three or four weeks at the end of which time no aphids could be found in the galls. For about three weeks scarcely an aphid could be found on the gooseberry plants. During the latter part of June the young aphids were again found on the gooseberries forming galls upon laterals and terminals. A series of wingless generations was then produced throughout the summer and autumn. During this time at least eight generations were observed and these continued to produce galls which practically covered the plants. This rapid multiplication continues until late October when a second winged generation is produced upon the gooseberry which either deposits the overwintering eggs or produces wingless females which deposit them. In some cases where winged females were confined to cages, eggs were deposited on the canes and no wingless forms could be found. On the other hand mounted winged females seem to exhibit wingless forms within the body. The writers are therefore in doubt regarding this point. Deposition of these eggs continues in the field until November 25th (1923).

In view of these rather brief life history notes, certain conclusions are quite obvious. First, the insect can and normally does live upon the gooseberry throughout the entire growing season in injurious numbers. Second, two winged generations are produced annually on the gooseberry, the autumn generation apparently depositing the overwintering eggs on the same food plant. Third, although the insect may have an alternate food plant upon which it spends a portion of its life cycle, all evidence points to a change in the specific plant of the same host only, and not to a change of alternate hosts during the winged stage.

Natural Enemies and Control

The only natural enemies that have been found during this study were the larvae of some of the smaller syrphid flies. They were present during a part of the summer in sufficient numbers to interfere seriously with breeding work. At certain times during the summer these larvae were so abundant that only a few aphids could be found on examination of a large number of galls. At other times the aphids were very abundant and the natural enemies quite scarce. Because of this fluctuation

it is impossible to predict the amount of benefit derived from this source of biological control.

Although experimental work is now in progress to determine a good chemical control, no adequate control measure has been devised to date and further work is necessary before presenting any data upon this subject.

VICE-PRESIDENT S. B. FRACKER: The next paper on the program is by T. J. Headlee.

CERTAIN DUSTS AS AGENTS FOR THE PROTECTION OF STORED SEEDS FROM INSECT INFESTATION

By THOMAS J. HEADLEE, Ph.D., *Entomologist, N. J. Agricultural Experiment Stations*

ABSTRACT

Common white edible beans are protected from later attack by the common bean weevil (*Bruchus obtectus*) when mixed in proper proportions with ground burned lime (CaO), hydrated lime Ca $(OH)_2$, calcium chloride $CaCl_2$, calcium sulfate $CaSO_4$, dolomite, Highland Clay, Bond D Clay and Milltown Ball Clay No. 9. The protection which is afforded by these materials is most marked in the case of Milltown Ball Clay No. 9, and seems not to be connected with atmospheric moisture or chemical state of the dust materials. The protective ability of these materials appears to be correlated with the degree to which they exhibit a colloidal character—the more colloidal the more effective, the less collodial the less effective. This physical character seems to operate through preventing the larva of the bean weevil from obtaining sufficient foothold upon the surface of the bean seed to drill its way into the bean. Milltown Ball Clay No. 9, which is the most colloidal of all the dust materials worked with, appears to afford protection to wheat and shelled corn from later attack by the angoumois grain moth (*Sitotroga cerealella*). This clay apparently also has an insect reducing power when not in direct contact with the immature stages of the insects themselves. This insect infestation reducing power appears both in the case of the bean weevil and the angoumois grain moth.

DUSTS AS INSECTICIDES

Chambers pointed out that maize commonly protected from weevils by mixing the grain with finely powdered wood ashes. He noted that the layer of wood ashes on the outside of the sack alone was effective. The editor of the publication, in which Chambers' article appeared stated that a layer of building lime on the floor of the storing place and between successive layers of bags gives satisfactory results.

Metcalf[2] pointed out that mixing air-slaked lime with cow peas in

[1]Chambers, F. Rhodesia Agr. Journal No. 3, p. 397–398. 1916. 1. c. p. 398.
[2]Metcalf, Z. P. Journal of Econ, Ent. Vol. 10. p. 74–87, 1917.

certain proportons resulted in a large measure of protection from the ravages of the bean weevils.

TABLE 1.[3] EFFECT OF MIXING VARIOUS DUSTS WITH DRY COMMON, WHITE BEANS WHEN THE CULTURE IS PROMPTLY SEEDED WITH 5 ADULT BEAN WEEVILS (BRUCHUS OBTECTUS) TEMPERATURES 80° F. AND HUMIDITY 73.4%

Proportion by weight Beans	Substance	Adults start	CaO	$CaCl_2$	$Ca(OH)_2$	Milltown Ball Clay No. 9
			Holes	Holes	Holes	Holes
32	1	5	30		66	
16	1	5	0	1	5	0
8	1	5	0	0	0	0
4	1	5	0	13	0	0
2	1	5	0	0	1	0
1	1	5	0	0	1	0

Thus it appears the mixing of common, white, edible beans with ground burned lime (200 mesh) (Calcium chloride (mostly 200 mesh), hydrated lime (mostly 200 mesh or finer), and Milltown Ball Clay No. 9 (200 mesh) in various proportions gives protection in the lower dilutions, ground burned lime and the clay giving the best results with the higher dilutions.

TABLE 2. EFFECT OF PLACING VARIOUS DUSTS IN THE SAME CONTAINER WITH BEANS SEEDED TO COMMON BEAN WEEVIL WHEN THE BEANS AND THE WEEVILS ARE SEPARATED AND FULLY PROTECTED FROM CONTRACT WITH THE DUSTS BY A THICK LAYER OF ABSORBENT COTTON. TEMPERATURE 80°F AND HUMIDITY 73.4 %

Proportion by weight Beans	Substance	Adults start	CaO	$CaCl_2$	$Ca(OH)_2$	Milltown Ball Clay No. 9
			Holes	Holes	Holes	Holes
4	1	15	50		257	
2	1	15	14	50	184	27
1	1	15	0	4	147	0
1	2	15	0	24	10	0
1	4	15	0	0	199	0
Control			60			

This table shows that ground burned lime (CaO) and clay have a decided protective effect even when not in contact with the beans.

[3]Throughout tables 1 & 2 each hole represents a distinct chamber from which the new beetle had already or not at that time emerged.

TABLE 3. EFFECT OF MIXING MILLTOWN BALL CLAY NO. 9 (200 MESH) WITH COMMON WHITE BEANS IN VARIOUS PROPORTIONS AND SEEDING EACH GROUP WITH 25 ADULT BEAN WEEVILS. TEMPERATURE 80° F. AND HUMIDITY 73.4% (NOV. & DEC. 1921)

Composition of the mixture		No. of Beans	No. infested	No. of Holes
Parts of Clay by weight	Parts of Beans by weight			
1	1	440	0	0
1	5	446	0	0
1	10	424	0	0
1	15	440	4	17
1	20	430	9	27
1	30	436	8	23
1	40	438	9	22
1	50	432	13	32
1	70	427	16	36
1	90	434	12	17
1	100	440	18	30
Check		426	86	86

Thus it appears that this clay affords complete protection when used at the rate of 1 part of clay to 10 parts of beans by weight.

In an effort to see what effect this clay would have against the angoumois grain moth (*Sitotroga cerealella*) on corn and wheat, mixtures of it and these grains were made. An ear of corn was rotated in the clay dust, placed in a jar and subjected to infestation by several pairs of moths. In due time a reasonably heavy infestation resulted.

Shelled corn was then tried and the results are shown in table 4.

TABLE 4. EFFECT OF MIXING MILLTOWN BALL CLAY NO. 9 (200 MESH) IN VARYING PROPORTIONS WITH SHELLED, YELLOW DENT CORN. TEMPERATURE 80° F. AND HUMIDITY 73.4% (1922)

Composition of Mixture		Period in days from introduction to exam.	No. of moths introduced	No. of moths at end	No. of corn grains	No. of corn grains infested
Parts of clay by weight	Parts of corn by weight					
1	1	29	4	4	153	0
1	5	26	4	4	160	0
1	10	24	4	4	149	0
1	15	32	4	4	154	0
1	20	32	4	4	154	0
1	30	36	2	2	148	0
1	40	36	2	2	149	0
1	50	32	2	2	152	0
Check		40	2	68	150	68

Thus it appears that Milltown Ball Clay No. 9 affords protection to shelled corn when mixed with the corn at the rate of one part of the

clay to 50 parts of corn by weight. This study does not show the minimum dosage.

The effect of mixing Milltown Ball Clay No. 9 with wheat and then examined and the results are set forth in tables 5 and 6.

TABLE 5. EFFECT OF MIXING MILLTOWN BALL CLAY NO. 9 (200 MESH) WITH WHEAT AND SEEDING WITH ONE AND TWO PAIRS OF THE ANGOUMOIS GRAIN MOTH. TEMPERATURE 80° F. AND HUMIDITY 73.4% (1922).

Composition of the mixture		Days from introduction to examination	No. of moths introduced	found	No. of wheat grains	No. of grains infested
Clay in parts by weight	Wheat in parts by weight					
1	1	29	4	4	1300	0
5	1	28	4	4	1300	0
10	1	30	4	4	1300	0
15	1	32	2	2	1300	0
20	1	33	2	2	1300	0
30	1	35	2	2	1300	0
40	1	35	4	4	1300	0
50	1	36	2	2	1300	0
Check		44	4	72	1300	48

TABLE 6. EFFECT OF MIXING MILLTOWN BALL CLAY NO. 9 WITH ALREADY INFESTED WHEAT. TEMPERATURE 80° F. AND HUMIDITY 73.4% (1922)

Composition of the mixture		No. of moths emerging	No. of parasites emerging
Parts of Clay by weight	Parts of Clay by weight		
4	1	2	2
3	1	3	0
2	1	6	0
1	1	4	0
1	2	3	0
1	3	8	0
1	6	5	1
1	8	9	5
1	16	12	0
Check		5	26

Thus it appears that mixing wheat with Milltown Ball Clay No. 9 at the rate of 50 parts to one by weight affords perfect protection. The minimum dosage did not appear in this study. It further appears that comparatively large dosages of clay slightly reduced the infestation itself.

From the data recorded in tables 1 and 2 it seems obvius that when common white beans are mixed with ground burned lime (CaO), Calcium chloride ($CaCl_2$), hydrated lime ($Ca(OH)_2$) and Milltown Ball Clay

No. 9 they are more or less protected from later infestation by the common bean weevil. It also seems that of the four substances enumerated ground burned lime (CaO) and Milltown Ball Clay No. 9 are most effective and give, at certain dilutions, perfect protection. Unfortunately, ground burned lime causes the seed to crack and fortunately Milltown Ball Clay No. 9 leaves the bean in an apparently perfect physical condition.

The data submitted in tables 3, 4, 5, and 6 indicate that Milltown Ball Clay No. 9, when mixed with common white beans, at the rate of one to ten will afford apparently perfect protection from later common bean weevil attack and, when mixed with shelled corn or wheat at the rate of at least one to fifty, will afford apparently perfect protection against subsequent angoumois grain moth attack. Most surprising of all, the data in tables 2 and 6 indicates that even when not in direct contact with the insect the clay is capable of exerting a reduction of infestation.

Relative Humidity

Prevention of common bean weevil attack on common white beans in storage by the maintenance of a low relative humidity, as set forth by Headlee,[4] when connected with Chambers' and Metcalf's experience, seem to indicate that the dusts tried at that time were acting through the maintenance of a low relative humidity, but when it was found[5] that the hygroscopic power of calcium hydroxide and Milltown Ball Clay No. 9 was extremely low and at the same time that they were effective insecticides against the common bean weevil, that idea had to be deserted.

Chemical Composition, Acidity and Alkalinity

An effort was then made to determine whether chemical composition, acidity or alkalinity had anything to do with protecting common white beans from infestation by the common bean weevil. All materials were ground to the same fineness (200 mesh). Four different kinds of material were used. Their composition, pH value and organic content are set forth in the following table:—

[4]Headlee, Thomas J. Journal of Econ, Ent. vol. 10 p. 34–37.
[5]Headlee, Thomas J. Report of N. J. Agr. Exp. Sta., year ending June 1921 p. 370–371.

TABLE 7.

No.	Name of Carrier	SiO_2 %	Fe_2O_3&Al_2O_3 %	CaO %	MgO %	pH	Loss on ignition
1	Highland Clay	52.59	33.25	0.95	0.22	7.5	10.50
2	Bond D Clay	68.00	21.90	0.30	0.20	7.0	8.00
3	Mill town Ball Clay No. 9	63.30	13.80	0.22	0.16	4.7	10.88
3A	Milltown Ball Clay	63.30	13.80	0.22	0.16	4.7	10.88
4	Calcium sulfate	0.02	0.00	41.14	0.00	7.5	
5	Sea Sand	98.04	1.02	0.03	0.40	7.0	0.70

These same materials were mixed with common white beans and seeded with ten adult beetles each. The results are set forth in the following table:—

TABLE 8.

No.	Acid reaction	Alkaline reaction	Neutral reaction	Material used Dust	Amt. beans grms.	Amt. Dust grms.	No. of beans penetrated	No. of Adults
1		+		Highland Clay	10	1	none	10
2			+	Bond D Clay	10	1	none	10
3	+			Milltown Ball Clay No. 9	10	1	none	10
3A	+			Milltown Ball Clay No. 9	10	1	none	10
4	+			Calcium sulfate	10	1	24	68
7	Check				10		18	77
8	Check				10		22	80

Thus it seems obvious that chemical composition, acidity and alkalinity have little, if anything, to do with the effectiveness of the dusts when used in comparatively low dilutions (one part of dust to ten parts of beans).

PHYSICAL CHARACTERS

The physical characteristics of the dusts were next examined. The clays were, of course, more colloidal than either the calcium sulfate or the sea sand. A study of the comparative colloidal character of the three clays used is set forth in the following table, which serves to show that Milltown Ball Clay No. 9 is the most colloidal of them all:

TABLE 9.

No.	Carrier	Flocculation measured by transparent liquid	Flocculation measured by sedimentation	Turbidity measured by residue in soil suspension (salts included)
1	Highland Clay	2	16	124
2	Bond D Clay	2	65	242
3	Milltown Ball Clay No. 9 mesh	2	75	246

TABLE 10.* EFFECT OF THE SIZE OF THE PARTICLE ON THE EFFECTIVENESS OF CERTAIN DUST MATERIALS

Dilution in parts by weight		Milltown Ball Clay No. 9 No. of exit holes					Highland Clay No. of exit holes					Bond D Clay No. of exit holes				
Clay	Beans	80 mesh	100 mesh	140 mesh	200 mesh	270 mesh	80 mesh	100 mesh	140 mesh	200 mesh	270 mesh	80 mesh	100 mesh	140 mesh	200 mesh	270 mesh
1	5	0	0	2	0	0	0	0	0	17	0	0	0	0	0	0
1	10	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0
1	20	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0
1	30	0	0	0	0	0	1	14	0	0	0	0	9	0	0	0
1	50	0	0	0	15	0	9	23	1	0	0	3	7	6	0	35
1	60	0	0	0	0	0	153	64	0	2	0	24	9	0	0	3
1	70	0	0	0	0	0	21	59	9	0	0	2	57	10	2	0
1	80	0	0	0	0	0	9	5	47	0	4	0	12	0	0	0
1	90	0	0	0	0	0	1	0	14	0	1	12	44	25	4	16
1	100	0	0	0	0	0	39	0	0	0	6	0	53	0	16	0
1	500	5	0	0	0	12	1	43	1	0	1	23	6	26	1	1
Check		154	28	39	118	92	122	21	177	105	43	58	195	34	105	58

		Hydrated Lime No. of exit holes					Land Plaster No. of exit holes					Dolomite No. of exit holes				
		80 mesh	100 mesh	140 mesh	200 mesh	270 mesh	80 mesh	100 mesh	140 mesh	200 mesh	270 mesh	80 mesh	100 mesh	140 mesh	200 mesh	270 mesh
1	5	23	0	28	4	21	0	30	25	1	0	2	0	0	0	0
1	10	22	0	2	12	22	5	34	49	6	0	20	4	0	16	1
1	20	25	11	5	36	59	0	56	7	3	0	7	11	16	4	0
1	30	18	34	0	40	3	7	11	84	19	0	2	0	7	17	0
1	50	33	90	26	120	53	74	110	134	0	7	0	24	4	50	0
1	60	101	27	15	102	126	101	103	132	17	12	51	30	0	54	17
1	70	153	52	124	38	163	17	33	53	62	21	7	24	18	75	58
1	80	33	25	35	96	78	1	99	5	17	0	0	0	30	13	9
1	90	218	12	84	159	148	6	77	48	9	3	60	15	80	25	40
1	100	122	0	49	162	92	12	13	7	55	15	11	6	9	37	51
1	500	166	27	20	173	22	28	128	62	62	57	42	105	39	61	12
Check		172	80	160	235	67	56	160	241	105	66	133	120	147	77	123

*Each culture was seeded with 10 adults of the common bean weevil and was kept during the summer at room temperature, changing to the constant of 80° F. when the necessity for artificial heat in the building arrived. The beans were the common white variety. An exit hole represents a new adult.

Calcium sulfate approaches the crystalloidal stage and sea sand is strictly a crystalloid. Examination of table No. 8 shows that while the clays in a dilution of one part to ten parts of common white beans gave perfect protection, calcium sulfate, in the same dilution did not effect anything like perfect protection.

The physical character of a dust material depends upon the physical character of the unit particles composing it and a study of the effect of different sized particles of Milltown Ball Clay No. 9, Highland Clay, Bond D Clay, Calcium hydrate, calcium sulfate and dolomite on the efficiency of dusts composed of these materials in preventing infestation of comomn white beans by the common bean weevil was undertaken. The following table will serve to set forth the results.

Of all the six dusts experimented with Milltown Ball Clay No. 9 is, without doubt, the most efficient, and 100 mesh material is apparently composed of the best size of particle.

Method by Means of Which Infestation is Prevented

Time has forbidden the study of the method by means of which infestation is prevented from including more than the common bean weevil on common white beans. Previous investigations had shown[6] that eggs were laid and that the eggs hatched but that no infestation took place.

For the purpose of discovering how the dusts kill the larvae a series of intensive observations were made on certain newly hatched larvae and the results are set forth in tables 11 and 12 and in the paragraph which immediately follows them.

Table 11. Record of One Just Hatched Larva which, when Just Out of the Shell, was Surrounded by a dust Ring of Milltown Ball Clay No. 9. Ring One-quarter of an Inch in Diameter

Time of observation 3-28-'23		Larval Activity
1:00	P. M.	Hatching completed
1:00–2:10	"	Remained attached to bean by caudal and moved body from side to side.
2:10–2:20	"	Moved in a complete circle within dust ring
2:20–2:35	"	Continued to crawl about with'n dust ring.
2:35–2:55	"	Repeatedly tried to crawl forward but seemed unable to grapple the surface of the bean because its holdfasts slipped.
2:55–3:20	"	Continued to crawl about within the circle of clay dust
3:20–3:40	"	Attached its caudal end and moved its body to and fro.
3:40–3:45	"	Crawled slowly about within the dust ring.
3:45–3:50	"	Caudal end attached to bean surface, body moved to and fro.
3:50–4:00	"	Caudal end attached but body quiet.

[6]Headlee, Thomas J. Rep't. N. J. Agr. Expt. Sta. for 1922.

4:00–4:10	"	Crawled about within the dust ring.
4:10–4:20	"	Larva crawled off the bean and fell into clay dust in the bottom of the chamber.
4:30	"	Replaced on the bean.
4:30–6:00	"	Caudal end attached, body moving to and fro.
3–29–'23		
7:30	A. M.	Larva dead at the spot where it was left at 6:00 P. M. the preceding day.

TABLE 12. RECORD OF TWO JUST HATCHED LARVAE EACH PLACED ON A BEAN AND SURROUNDED BY A DIRT RING ABOUT ONE QUARTER OF AN INCH IN DIAMETER. LARVA NO. 1 WAS SURROUNDED BY A RING OF MILLTOWN BALL CLAY NO 9 DUST AND LARVA NO. 2 BY A RING OF HYDRATED LIME.

3–29–'23		
1:45	P. M.	Larvae placed.
1:45–2:15	"	No. 1 larva crawls about within the dust ring.
1:45–2:00	"	No. 2 larva crawls about within the dust ring
2:15–2	"	No. 1 larva stops crawling
2:00	"	No. 2 larva looks as if it were trying to drill into the bean
2:30	"	No. 1 larva pushes into the dust ring
2:30	"	No. 2 larva pushes into the dust ring.
3:00–4:30	"	No. 1 & No. 2 larvae so covered by dust that they can hardly be seen.
4:30–5:00	"	No. 1 & No. 2 larvae moving under the dust
3–30–'23		
8:00	A. M.	No. 1 & No. 2 larvae dead at the points where they were observed at 5:00 P. M. the preceding day.

On April 5, 1923 a larva was observed drilling into a bean where the bean surface lay adjacent to another bean. One and one-half hours were required for the larva to bury itself in the bean. In this instance the beans had not been treated with dust of any kind.

The writer's observations indicated distinctly that the larva was unable to grapple the bean surface because of the slipping of the fine particles of dust which its claws, and frequently its anal sucker seized upon. In fact, in many instances the writer saw the larva extend the front end of its body, attempt to lay hold of the bean surface and pull the caudal end forward. In most cases the front end simply slipped backward without, in any way, lifting the caudal end. Likewise, he observed that the front end would sometimes become seated, the anal would be pressed down on the surface of the bean, and an attempt made to shove the front end forward. In most of these instances instead of the front end going forward the anal sucker slipped backward.

In view of these observations, the writer believes that the inability of the larva to enter the bean which has been coated with a dust is due to its inability to grapple the surface of the bean firmly enough to give it a

foothold. The larva slowly wears itself out and died before it is able to penetrate.

Unfortunately the above recorded data fails to show clearly just why Milltown Ball Clay No. 9 exerts a destructive effect when not in immediate contact with the larvae or pupae of the bean weevil and angoumois grain moth. So far as the writer can see, there is nothing in the known chemical or physical composition of Milltown Ball Clay No. 9 that would account for its ability to destroy immature forms of the common bean weevil or angoumois grain moth, when not in contact with them, except possibly radio-activity. The material is somewhat radio-active.

Effect of this material upon germination or upon the milling and baking has not been determined.

MR. H. F. DIETZ: I would like to ask if this treatment has any effect on the milling quality of the wheat?

MR. T. J. HEADLEE: None that we can determine.

VICE-PRESIDENT S. B. FRACKER: The next paper is by T. L. Guyton.

NOTES ON THE USE OF CHLORINE GAS AS AN INSECTICIDE

BY T. L. GUYTON, *Penna., Bureau Plant Industry*

Trials in the use of chlorine gas as an insecticide in the control of the Angoumois grain moth (*Sitotroga cerealella*) resulted in the loss of germination to the treated wheat and an incomplete kill of the moths. In one case where the grain had a moisture test of 17% the treatment resulted in the charring of the treated sample.

An agent of the Electro Bleaching Gas Company called the writer's attention to the possibility of using chlorine gas as an insecticide in the control of the Angoumois grain moth and offered to furnish a tank of the gas for trial.

On December 1922 some wheat was obtained in the vicinity of Carlisle, Penna., just as it came from the thrashing machine, and another sample was obtained from a flour mill nearby. The sample obtained from the thrashing machine was heavily infested with the moth. The wheat weighed only thirty-six pounds to the bushel, had a moisture content of seventeen per cent and a germination test of sixty-nine per cent. The wheat from the mill weighed fifty-six and three-tenths pounds to the

bushel and gave a moisture test of eleven and nine-tenths per cent and a germination test of 91%.

A glass jar holding about one-half bushel was filled level full of wheat taken from the mill. A rubber hose was passed from the chlorine tank to the bottom of the jar. The gas was allowed to run into the jar until the presence of the gas was decidedly noticeable at the top. Time required was 28 minutes. Eight samples were taken at intervals of five, ten, fifteen, thirty, and sixty minutes, three hours, four hours and twenty-two hours. After removal from the fumatorium the samples were aerated by pouring from one vessel to another several times in the presence of a breeze.

An attempt was made to repeat the operation, using the wheat taken from the thrashing machine the previous day. The gas was turned on and strips of paper saturated with ammonium hydroxide were placed as indicators on the top of the grain. After the flow has continued about one hour no chlorine could be detected at the top of the jar, but the jar was quite warm, on the sides near the bottom. The gas was at once shut off. Upon examination the wheat in the bottom of the jar was found completely charred and there was a distinct odor of hydrochloric acid. (The jar was undisturbed for a few hours and then examined. The wheat was entirely ruined).

Control in first lot.

The samples taken were placed in a dark, warm cupboard. On January 2nd, 1923, the five, ten and fifteen minute samples contained living moths. Moths continued to emerge from these samples. On January 29th all the samples contained some living moths.

Effect on germination.

Check sample gave a germination of.....91%
Five minute sample gave a germination of.....26.5%
Ten minute sample gave a germination of.....29.5%
Fifteen minute sample gave a germination of.....17.0%
Thirty minute sample gave a germination of.....16.5%
Sixty minute sample gave a germination of.....12.5%
Three hour sample gave a germination of.....7. %
Four hour sample gave a germiniation of.....11.5%
Twenty-two hour sample gave a germination of.....10.5%

President Ruggles resumes the chair.

PRESIDENT A. G. RUGGLES: The next paper is by W. E. Britton.

AN ASIATIC BEETLE (*ANOMALA ORIENTALIS*) IN CONNECTICUT

By W. E. Britton, *State Entomologist, New Haven, Conn.*

Abstract

Specimens of *Anomala* collected in a nursery in New Haven in 1920 and 1921 were identified in May, 1922, as *Anomala orientalis*. In 1923, white grubs injured the roots of grass in lawns in the vicinity. Adults were reared and proved to be this species.

On July 16 and 29, 1920, and July 26, 1921, Messrs. M. P. Zappe and B. H. Walden, Assistant Entomologists, collected on weeds and grass in a nursery in New Haven, some beetles which they recognized as belonging to the genus *Anomala*, but differing from any speices in the Station collection. At that time Mr. Charles Schaeffer of Brooklyn, N. Y., was engaged in studying the American species of *Anomala*, so we sent some of these specimens to him. He was unable to identify the newly-collected material, but stated that it was different from any American species that he has seen, and that probably it had been introduced from some other part of the world. Later he sent the material to the British Museum, where it was identified by Mr. Arrow. On May 17, 1922, I received from Mr. Schaeffer a letter reading as follows:—"He identified it as *Anomala orientalis* Waterhouse, a Japanese species, he tells me, which is reported as a destructive pest on sugar cane in the Hawaiian Islands. If it should get a good foothold here it may prove as injurious as *Popillia japonica* (the Japanese beetle) in New Jersey, also an introduced species."[1]

Late in the fall of 1922, one of my neighbors complained to me that white grubs were injuring his lawn and on November 2, I visited his place and collected a few specimens. At the laboratory we took them to be ordinary white grubs, though they were rather small and varied considerably in size and were quite active. These grubs all died, probably having injured each other with their mandibles, as we afterward learned they are apt to do when confined together with little soil .

The spring of 1923 had scarcely opened when other residents of the neighborhood also complained of similar injury to their lawns, and altogether perhaps a dozen such complaints were received. There were many lawns where the grass was entirely killed in patches eight or ten feet in diameter, and in other places a part of the grass still remained green. Now this neighborhood is in the same locality where the beetles

[1]See Journal of Economic Entomology, XV, 311, 1922: Report Connecticut Agricultural Experiment Station for 1922, 345, 1923.

were collected in 1920 and 1921, and we suspected that there might be some connection between them.

More larvae were collected but were at once separated so that they could not injure each other, and on July 24, 1923, adult beetles emerged. Prior to their emergence, specimens of the larvae were sent to the Bureau of Entomology at Washington, and identified provisionally as *Anomala orientalis* Waterhouse by Dr. A. G. Boving. The beetles reared here were at once recognized as the same as those which had been collected, namely, *Anomala orientalis* Waterhouse.

The locality where the collections were made was until two years ago a part of a nursery which several years ago imported many shipments of plants from Japan, and some of the plants came in balls of earth. This nursery has now removed to Woodmont, nearly six miles distant, and dwelling houses now occupy the land formerly covered with nursery stock. The infested lawns are not on the nursery grounds but across the street and extend for one or two squares northward and somewhat eastward from the point where the beetles were collected in the margin of the nursery.

The scouting which has been done indicates that the injured lawns are all in a residence section and within five or six city squares or blocks, but we do not know how widely this pest may have been distributed from the nursery, or how far the infestation may have spread beyond the area where injury is apparent, as a small number of grubs per square yard would not kill the grass, and therefore would not be noticed.

When this insect first appeared in Hawaii some ten years ago, it was so destructive to sugar cane that parasites were imported from Japan in the hope of controlling it. One of these, a Hymenopterous parasite, *Scolia manilae* Ashm., was established in Hawaii during the years between 1914 and 1915, and proved effective. From an area where in 1917, 3,500 *Anomala* grubs were collected, this parasite had so thoroughly reduced the pest by 1919, that by careful search only four grubs could be found. *Scolia manilae* is one of the parasites introduced into New Jersey on account of the Japanese beetle, but does not survive the winters. Consequently we can hope for little help from this insect, though there is a possibility that some of our native species of *Scolia* or *Tiphia* may attack the grubs.

The beetles do not seem to fly, but keep near the ground in the stubble or crawl upon the stems of grass and weeds. This habit is a distinct advantage where control measures are attempted.

MR. E. P. FELT: I would like to ask if any attempt has been made to eradicate this new species.

MR. W. E. BRITTON: We have carried on a few experiments in small areas to determine the best method of killing the grubs. The work is difficult, however, because there are many small yards that children are playing in and it is dangerous to use cyanide or similar poisons. The matter has been reported to the Federal Horticultural Board but no decision has been reached as to whether an attempt should be made to exterminate this insect.

PRESIDENT A. G. RUGGLES: The next paper will be read by C. L. Corkins.

GRASSHOPPER BAITS, WITH SPECIAL REFERENCE TO SODIUM ARSENITE

BY C. L. CORKINS, *State Entomologist University of Wyoming*

ABSTRACT

Experimental work with grasshopper baits was carried on over a period of three years with a two-fold purpose in view, first, to determine the merits, under Colorado conditions, of the ingredients commonly used in standard grasshopper baits; and second, to find a more practical killing agent than white arsenic.

Amyl acetate and salt are essential elements of an efficient grasshopper bait. A combination of bran, arsenic and water only, gave surprisingly good results, but not good enough for practical usage. The value of expensive molasses is doubtful. Only when cheap sugar beet refuse molasses can be obtained does it seem justifiable to include it. The substitution of 50% by bulk of sawdust in place of bran in baits to be used on lands of low productive value per acre, is recommended. Fermentation of the bait to replace the use of amyl acetate gave poor results when used for our economic species of *Acrididae* but excellent results in the case of *Anavrus simplex*.

The superiority of sodium arsenite over white arsenic was established by two years of experimentation and its extensive use in two large epidemics of grasshoppers. As a killing agent, it is fully as efficient as the best mixed white arsenic and is more practical in mixing, cost and handling.

(Withdrawn for publication elsewhere).

PRESIDENT A. G. RUGGLES: We will now hear the next paper by R. C. Smith.

CAENURGIA ERECHTEA (CRAM) (NOCTUIDAE) AS AN ALFALFA PEST IN KANSAS[1]

By ROGER C. SMITH, *Kansas State Agricultural Experiment Station*

ABSTRACT

A common insect in alfalfa, clover and pastures of Kansas; occasionally numerous but not seriously injurious. The name "Forage looper" is proposed for it. Overwinters as a pupa and possibly as a partly grown larva. Three and a partial fourth generations annually. All stages described and biological data summarized. Natural enemies effective. Cutting alfalfa results in death of many of the larvae.

During the progress of a Kansas experiment station project on alfalfa insects, it was observed that *Caenurgia erechtea* (Cram.), better known as *Drasteria erechtea* Cram. was present constantly in alfalfa fields and occasionally in considerable numbers. It has been reported frequently in the literature as occurring in clover fields, but always as a minor pest. In Virginia, the writer observed this insect during two years in clover fields, but it was never seriously abundant. It was also very common in grass pastures and was known locally as the "grass worm."

Several common names have been proposed for this insect. Comstock (1917) suggests "Clover looping owlet moth;" Saunders (1875) the "Common Drasteria," and O'Kane (1912), the "Northern grass worm." All of these are open to objection and criticism in the light of later knowledge so the author proposes the name "Forage looper" because the larva has a looping gait, and all stages occur in pasture, grassy places, fields of clover and alffala. This name was submitted to the committee on nomenclature, and was approved by it.

The other well known species of Caenurgia, *crassiuscula* Haw. is very uncommon in Kansas. It was collected only a few times and was never reared. The larval characters are not known to the writer.

This is one of our common noctuids, and published records show the distribution to be the Atlantic states to Florida, west to British Columbia and California. It is apparently plentiful throughout its range. In Kansas it is occasionally the most abundant lepidopterous insect in alfalfa; therefore, considerable rearing and field observations were carried on for a period of four seasons. While not a major pest of the

[1]Contribution No. 325, from the Entomological Laboratory, Kansas State Agricultural College. This paper embodies some of the results obtained in Experiment Station project No. 115.

The writer wishes to acknowledge his indebtedness to certain undergraduate and graduate students in the field and rearing work. Chief among these is Mr. Edgar Davis who assisted especially in the rearing work and preparation of the tables. Further acknowledgment is made to Mr. S. Fred Prince for the drawings, to Dr. W. T. M. Forbes, the United States Bureau of Entomology for determinations, and the latter for Mr. Heinrich's work on the setal maps.

crop, it is one of the large group taking its toll from the crop and it may be of greater importance in the future.

The best published accounts of this insect are the papers of Saunders (1875), French (1884), Osborn and Gossard (1891), Slingerland (1892) and Webster (1898).

Seasonal History

The insect overwinters mainly as a pupa in a silken cell just under the surface of the ground or in a cocoon of silk and dried leaves at the base of the plant. Pupae have been dug up in the spring in overwintering cages and the moths emerged. While it is believed that the bulk of the overwintering forms are pupae, it is possible that half grown larvae may sometimes survive the winter, because a group of larvae lived in an outdoor cage from October 22, 1922, to the latter part of February, 1923. Partly grown larvae of this species can be collected in alfalfa fields by sweeping as late as December 1st, but it is believed they all or nearly all perish ordinarily before this date. The moths appear in the spring about the time alfalfa is beginning to grow.

The first moths were taken on March 31, 1922 and April 8, 1923. The second generation of moths appears at Manhattan about June 10. This is a light brood, and the larvae are always scarce during this period. The second brood reaches maturity about July 14th. The first of the third brood appears as adults about August 15. At this time and subsequently all stages occur in the fields and the broods overlap. These moths deposit eggs the latter part of August and during September. Some of the third generation pupae overwinter, others give rise to adults which deposit eggs for a partial fourth brood. There are thus three generations in Kansas of approximately a month's duration each and a partial fourth, the greater number of larvae of which succumb to the cold of November and December.

Life History

The length of life in the various stages in both indoor and outdoor rearings is shown in Table I.

The width of the head capsule and total length in the various stages of larvae are shown summarized in Table II.

Life Stages. This insect is easily reared, the usual rearing methods proving satisfactory. Eggs and pupae are not easily collected in the field, but are readily obtained in cage rearings. The egg (Fig. 11, 8) has been described by French (1884) and Riley (1885). They are

TABLE I. SUMMARY OF LENGTH OF STAGES IN THE LIFE HISTORY

Stage	Longest days	Shortest days	Average days	Number of Individuals Averaged
Egg	6	4	4.8	76
First instar larva	6	3	4.1	72
Second " "	6	2	3.0	70
Third " "	5	2	3.3	63
Fourth " "	6	2	3.7	52
Fifth " "	6	3	4.4	33
Sixth " "	7	3	5.2	15
Prepupa	9	1	2.7	13
Pupa (Summer)	13	10	11.4	8
Adult	23	0	13.5	54
Totals	87 days	30 days	56.1 days	

TABLE II. SUMMARY OF INSTAR MEASUREMENTS

Stage	Dimension	Greatest mm.	Least mm.	Average mm.	Number of Individuals Averaged
First instar larva	length	7	3.7	5.22	45
" " "	width of head	0.4	0.3	0.39	45
Second instar larva	length	11	6.	7.66	45
" " "	width of head	0.6	0.46	0.58	45
Third instar larva	length	17	8	12.2	39
" " "	width of head	0.93	0.66	0.83	39
Fourth instar larva	length	26	11	17.2	36
" " "	width of head	1.53	1.14	1.31	38
Fifth instar larva	length	34	18	26.3	27
" " "	width of head	2.0	1.66	1.89	28
Sixth instar larva	length	43	23	34	20
" " "	width of head	2.87	2.13	2.5	20

deposited singly or in groups on any part of the plant, but especially on the leaves.

As embryological development proceeds, the eggs become spotted with brown. These spots are irregular in shape, of different sizes and scattered irregularly, but their relative positions in different eggs are the same. The largest one is near the micropyle and is always present. Between these spots are numerous, conspicuous, whitish, flaky spots beneath the chorion. The larvae hatch by eating nearly circular holes in the egg shells 0.25 mm. in diameter. Upon emerging, the larvae generally devour a portion of the remaining empty egg shell. They may devour all but the attached portion of the chorion.

Larvae. They are longitudinally striped (Fig. 11, 3, 4, and 7) or banded, and walk with a looping gate. All stages may be readily col-

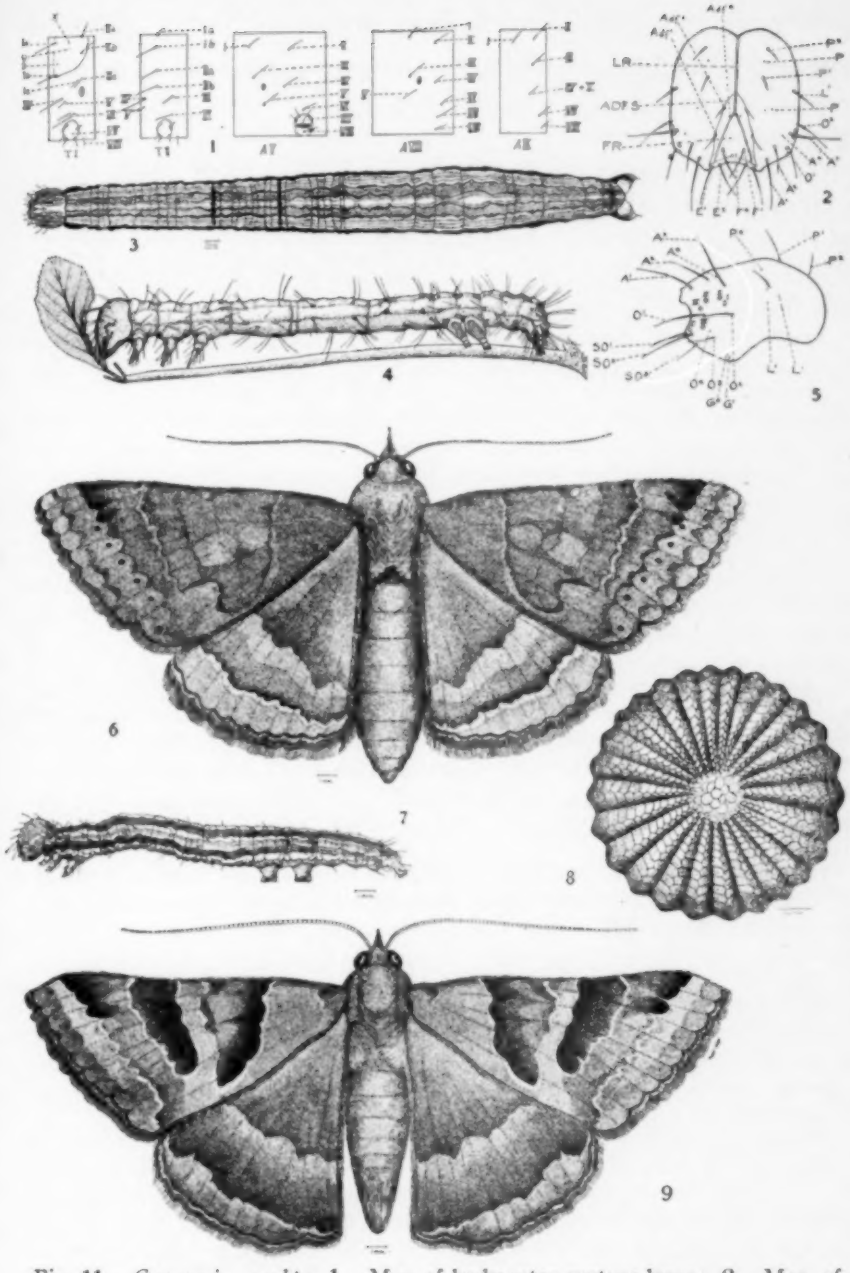


Fig. 11.—*Caenurgia erechtea* 1. Map of body setae mature larva; 2. Map of head setae, mature larva; 3. Color pattern of grown larva, dorsal view. Note two intersegmental darkened areas; 4. First instar larva; 5. Lateral view of head, setal map, 6. Female showing color pattern; 7. Lateral view of grown larva; 8. Dorsal aspect of egg; 9. Male showing color pattern. Most drawings, by Mr. S. Fred Prince; 1, 2 and 5 by Carl Heinrich.

lected by sweeping alfalfa with a net, while the large ones are sufficiently conspicuous as they rest extended along a leaf or stem to make possible their collection by hand. The larvae have been described as to coloration, size and general features by French (1884).

It is well known that color bands vary in number and shade; therefore, at the writer's request, Mr. Carl Heinrich of the U. S. National Museum prepared a description of setal characters which is given verbatum, accompanied by figures, 1, 2, and 5:

"Body cylindrical, slender, scarcely tapering at caudal end; abdominal segments much elongated. No secondary hair. Legs normal. Prolegs on 5th, 6th, and 10th abdominal segments only. Crochets uniordinal, in a mesoseries. Prothoracic shield narrow, undivided, not extended laterallyto include setae Ic to IIc. Spiracles oval, rather large; that on prothorax 2 times and that on 8th abdominal segment 1½ times as large as others on abdominal segments. Skin smooth.

Body setae short; tubercles very small with no surrounding chitinizations; IV on abdominal segments 1 to 8 posterior to the spiracle, far removed from V; V antero-ventrad of the spiracle on abdominal segments 8 and 1 to 4, directly ventrad on 5 to 7; only two prespiracular setae on prothorax (IV and V), III absent; IV and V united on abdominal 9; II antero-ventrad of the spiracle on abdominal segments 1 to 8, farthest forward on segments 1 to 4; IIIa not distinguishable; I and II nearly on a level on most abdominal segments, II distinctly more laterad, only on segments 7 and 8; group VI bisetose on prothorax, unisetose on remaining thoracic segments and on abdominal segments 1 to 8; absent on abdominal 9; group VII trisetose on abdominal segments 1 to 6, unisetose on 7, 8 and 9; prothorax with IIa higher than Ia, Ic and IIc closely approximate and well separated from the other setae, Ib also well separated, punctures X and Y well back of seta Ia, Y lying midway between Ia and IIb; meso- and metathorax with Ia and Ib well separated, also IIa and IIb.

Head capsule spherical; longer than wide; greatest width well forward of middle; incision of dorsal hind margin slight. Frons (FR) triangular, slightly longer than wide, not reaching middle of head. Adfrontal sutures (ADFS) extending to middle of head. Longitudinal ridge (LR) long, about 1½ times length of frons.

Ocelli six; lenses well defined; ocelli I to IV grouped together; V and VI well separated from the rest. Epistoma normal.

Frontal punctures (Fa) close together; slightly forward of frontal setae (F^1); distance separating frontal seta (F^1) and first adfrontal seta (adf^1) less than that separating adf^1 and adf^2 posterior to beginning of longitudinal ridge; puncture adf^a approximate to adf^2.

Epicranium with the normal primary setae and punctures, but without distinguishable ultra posterior setae or punctures. Anterior setae (A^1, A^2, A^3) forming an obtuse angle; anterior puncture (A^a) postero-laterad of A^2. Lateral seta (L^1) well back on head, widely remote from A^3; lateral puncture (L^a) postero-ventrad of L^1, approximate. Posterior setae (p^1, p^2) behind middle; puncture p^a before middle, on the level of adf^2; puncture p^b lying between p^1 and p^2. Ocellar setae (O^1, O^2, O^3) triangularly grouped; O^1 lying close to and below ocellus IV; O^2 postero-ventrad of ocellus 1, in a line with ocelli I and II; O^3 antero-ventrad of O^2, remote; ocellar punct-

ure (O) lying between O^2 and ocellus VI. Subocellar setae (SO^1, SO^2, SO^3) triangularly placed and approximately equidistant; subocellar puncture not distinguishable. Genal seta and puncture (G^1, G^a) minute; puncture before the seta."

The larvae during the first and second instars eat the epidermis from the leaves while later instars skeletonize the leaves. The larger larvae, when abundant may entirely defoliate the plant. This was never observed in fields but often occurred in cages. The larvae hold fast by means of the abdominal legs, then reach out in all directions for food or support. When disturbed they curl up in a distinctive manner. The head and thorax are bent ventrad, bringing the venter of this region in contact with the venter of the abdomen. When not feeding, they usually remain fully extended and motionless on leaves or stems near the top of the plant.

In the early spring and late fall, especially the latter, the larvae are smaller and much darker colored. They are banded as during the summer, but there is more black and red in the bands. The larvae resemble rather closely, as to coloration, the larvae of *Laphygma flavimaculata* Harv. and *Diallagma angustiorata* Grt.

Pupa. After a minimum period of two weeks, the larvae are fully grown and make preparations for pupation. The larvae tie leaves, stems, earth or excrement together with silk, making a concealing cocoon in which they rest one or two days as prepupae. During this time the coloration becomes subdued, the body shorter and somewhat spindle shaped. The pupae are whitish, appearing as if a brown cocoon had become moldy or stained with a whitish coat, and are about 15 mm. in length. Pupae in the field sometimes occur among the leaves of the plant, but more commonly they are under the plant among the leaves and trash on the surface of the ground. Overwintering pupae are found below the surface of the soil, usually about two inches.

The Adult. The adult has been described and figured several times, but usually only the male is figured (except Webster, 1898, and Holland: Moth Book, pl. XXX, fig. 14). Since the coloration in the two sexes is so different, both are figured here (Figs. 11, 6 and 9). They are rather swift fliers and may be mistaken, especially the female, for the moth of the corn earworm (*Chloridea obsoleta* Fab.). When disturbed they fly swiftly a short distance, alighting on the upper sides of exposed leaves, low down on the plant or on the ground. Their flight is jerky and somewhat erratic. They are attracted somewhat to lights and various baits placed in cone traps. Vinegar and molasses was apparently more attractive than banana oil, molasses, sugar water, or water.

The moths can be kept alive in cages, usually without much difficulty, by feeding them dilute sugar water or placing in the cage a bouquet of alfalfa blossoms. The average length of life of fifty-four moths was 13.5 days. The longest period any moth remained alive was 27 days.

The maximum number of eggs obtained from any moth in these rearings was 588. The average of 25 moths kept under as nearly optimum conditions as could be provided was 181 eggs. Records of fifty to one hundred eggs deposited in one night by a single female were common, and above a hundred not rare. The largest number obtained from one individual in one night was 185. Nothing unusual or different from closely related moths was observed regarding oviposition or copulation.

The moths are largely inactive during the day, flying only when disturbed. They are active on cloudy days and in the evenings when they can be observed feeding at the blossoms of alfalfa and various weeds in alfalfa fields.

In the autumn and early spring, the moths are smaller and darker colored, a condition pointed out by Walsh and Riley (1869). These darker forms have been given the varietal name of *parva* by Blackmore (1920).

Natural Control

The eggs are parasitized by *Trichogramma minutum* Riley. Since eggs are so rarely found in the field, no definite data on natural parasitism is available Parasitism can be readily induced in the laboratory by exposing eggs one or two days old to the parasites. The eggs turn black and one to four adults emerge in about eight days through a hole gnawed in the side of the egg.

Larvae are parasitized by Tachinids. Relatively few adult parasites have been obtained, though efforts were made to rear a great many from parasitized larvae. *Winthemia quadripustulata* Wied. was obtained three times. Parasitism was never observed to be an important factor.

The larvae are subject to a bacterial wilt which kills many in salve box rearings. A somewhat lesser number succumbed in cage rearings. It was frequently observed in the field, but is apparently dependent on weather conditions.

Birds pick up these larvae along with other lepidopterous larvae in alfalfa. Among those observed to feed upon such larvae are grackles, robins, English and other sparrows. Certain Nabids and Reduviids,

especially *Nabis sp.* and *Sinea diadema* (Fabr.) were often observed to feed on small larvae and it is believed that they are the most important of the predacious enemies.

Artificial Control

During these observations, artificial control has never been necessary. It was observed in fields and cage experiments, however, that most larvae perish when the crop is mowed. The larvae may be killed by the heat in twenty minutes to an hour, during the hottest part of the summer. Generally, however, the larvae begin to migrate from the field and perish from heat, starvation, or are picked up by predacious enemies.

Late fall and early spring plowing of infested clover fields recommended by several writers is scarcely practicable in alfalfa growing.

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[The European Corn Borer papers were presented at this point in the program. They were published in the February issue, pp. 112–159, as directed by vote of the association. EDITOR.]

PRESIDENT A. G. RUGGLES: The next paper will be presented by J. W. McColloch.

THE TIME OF PLANTING CORN AS A FACTOR IN CORN-EAR WORM CONTROL[1]

By J. W. MCCOLLOCH, *Kansas State Agricultural College*

ABSTRACT

Experiments which have been under way at the Kansas Station for ten years show that there is a definite relation between the date of planting corn and injury by corn-ear worm, *Heliothis obsoleta* Fabr., As a rule, the date of minimum ear worm injury and maximum yields coincide. The problem has been studied from several angles and these are discussed briefly in this paper.

In 1909 the Department of Entomology of the Kansas State Agricultural College began an investigation to determine the relation existing between the time of planting corn and the amount of corn earworm injury. Previous studies had shown that there was little hope of effecting a complete control of this insect, but that injury could be materially reduced by regulating the date of planting. The general plan of the experiment and the results of the first year were presented before this association in 1910[2] and it is the purpose of this paper to summarize the results obtained during the ten-year period 1909 to 1919.

PLAN OF THE EXPERIMENT

Each year this investigation was based on a series of five plots of corn planted at intervals of 15 days, beginning the middle of April. Three standard varieties of corn; namely, Boone County White, Kansas Sunflower, and Hildreth were grown in each plot throughout the experiment, and Commercial White was added in 1913. Each variety was planted in a three-row series, the rows varied from 100 to 200 feet in length during the different years, but were the same length each year, so the results are comparable. Plantings were made on April 15, May 1, May 15, June 1, and June 15. This experiment was conducted on the same area during the last eight years and the land was handled in the same manner as is usually followed by the average farmer. The rows

[1]Contribution No. 329, from the Entomological Laboratory, Kansas State Agricultural College. This paper embodies some of the results obtained in project No. 9 of the Kansas Agricultural Experiment Station

[2]Headlee, T. J., Notes on the Corn Earworm. Journ. Econ. Ent., 3:149–157, 1910.

were 40 inches apart and the hills 36 inches. Shortly after coming up, the corn was thinned to two plants in a hill.

Presentation of Data

The problem of reducing earworm injury to corn by varying the date of planting involves a study of many factors. Because of the variation in climatic conditions and in the abundance of the insect in different years, any recommendations should be based on the average of a number of trials. The period covered by this study represents five good corn years, two fair years, and three years when the yields were very poor. From the standpoint of the abundance of the earworm, there were five years of severe injury, three of moderate injury and two when the infestation was light.

Data were taken on all phases of climatic conditions and plant growth which are associated with earworm activities. Since space will not permit of a full discussion of the data, emphasis is placed on the yields and the percent of ears injured, and the data relating to these two points are summarized in Table I. The results are also arranged to show the frequency with which maximum yields and minimum injury were obtained with relation to the date of planting.

An analysis of the data presented in Table I shows that, from the standpoint of maximum yield and minimum earworm injury, corn should be planted between April 15 and May 1 at Manhattan, Kansas. The plots planted May 1 show an average increase in yield over those of April 15 of from 3.4 percent in the case of Kansas Sunflower to 15.5 percent for Boone County White. At the same time there was a decrease in the number of ears injured of from 2.3 to 3.4 percent for all varieties except Hildreth. The yields of the May 15 plantings were from 3 to 5.5 percent lower than those of May 1, while the earworm injury was from 12.6 to 15 percent higher. After May 15 the yields decreased rapidly with the delay in planting and the injury increased.

While the average yield for all varieties during the ten-year period was highest for the May 1 planting, yet the data show that maximum yields were obtained with greater frequency in the April 15 plots. In the case of the number of ears injured, however, the frequency data favor the May 1 plots.

In addition to the data presented in Table I, notes were taken on the date and period of silking, number of eggs deposited on each variety, percent of grain injury and number of overwintering pupae. The results of the study of silking and number of eggs deposited were dis-

TABLE I. A SUMMARY OF THE YIELDS AND EARWORM INJURY OF DIFFERENT VARIETIES OF CORN PLANTED AT DIFFERENT DATES AND THE FREQUENCY WITH WHICH MAXIMUM YIELDS AND MINIMUM INJURY WERE OBTAINED. 1909–1919.

Planted	Yield in pounds				Per cent of Injury			Frequency	
	Total	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum Yield	Minimum Injury
Kansas Sunflower									
April 15	988	123	17	98.8	96.0	48.5	68.5	5	4
May 1	1023	322	14	102.3	100.0	39.4	65.1	2	5
May 15	968	315	4	96.8	100.0	35.7	77.8	1	1
June 1	859	261	1	85.9	100	44.2	90.0	1	0
June 15	776	240	0	77.6	100	87.4	96.6	1	0
Hildreth									
April 15	1078	390	8	107.8	100	32.8	70.9	4	4
May 1	1155	319	4	115.5	100	31.5	72.0	2	5
May 15	1120	377	5	112.0	100	50.4	85.0		
June 1	890	241	1	89.0	100	58.5	92.2	2	
June 15	628	157	0	62.8	100	80.0	94.5	2	1
Boone County White									
April 15	918	264	17	91.8	98	41.9	66.0	5	4
May 1	1086	322	10	108.6	100	31.6	63.4	1	5
May 15	1027	315	7	102.7	94.7	35.7	76.0	2	
June 1	911	258	2	97.1	100	46.0	90.6	1	
June 15	863	236	0	86.3	100	79.0	95.7	1	1
Commercial White									
April 15	789	323	21	112.7	97	30.3	67.2	3	2
May 1	828	401	12	118.3	100	27.4	64.9	1	4
May 15	800	363	4	114.3	100	32.6	79.9	1	
June 1	711	340	1	101.6	100	44.7	88.5	1	
June 15	689	259	0	98.4	100	83.8	94.4	1	1

cussed in a previous paper[3] in which it was shown that the number of eggs deposited on a variety was correlated with the time and period of silking and this in turn influenced the infestation. From the standpoint of the number of eggs deposited, it was found that Boone County White should be planted between April 15 and May 1; Commercial White about May 1; and Kansas Sunflower and Hildreth between May 1 and May 15.

The determination of the percent of grain injured supports the results already presented in that the May 1 plots had from 2 to 3 percent of the grain destroyed, while from 4 to 6 percent was injured in the April 15 plot, and from 8 to 12 percent in the plantings of May 15 to June 12. Incidentally, it might be mentioned that the May 1 corn was comparatively free of the various molds and fungi which usually accompany earworm injury.

The number of overwintering pupae in a square rod of soil in each planting was determined during several years of the experiment. The results show that the number of pupae increased with the delay in planting. The first three plantings averaged from two to four living pupae per square rod, while the later plots had from eight to twelve.

Summary

An experiment to determine the best time to plant corn to obtain maximum yields and minimum earworm injury was conducted at Manhattan, Kansas, for a period of ten years. Four standard varieties of corn were used and data were taken on all phases which are associated with earworm activities. An analysis of all the data obtained in this study shows that May 1 is the optimum date to plant corn, although the results secured in the various phases of the investigation indicate that this date actually lies somewhere between April 15 and May 1. Experiments are now under way to determine the exact date when each variety of corn should be planted in Kansas to obtain the best yields and the lowest amount of earworm injury.

President A. G. Ruggles: The next paper is by Leonard Haseman and S. W. Bromley.

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[3]McColloch, J. W. A Study of the Oviposition of the Corn Earworm with Relation to Certain Phases of the Life Economy and Measures of Control. Journ. Econ. Ent., 13:242–255. 1920.

CONTROLLING CHINCH BUGS IN MISSOURI WITH CALCIUM CYANIDE

By LEONARD HASEMAN AND S. W. BROMLEY

ABSTRACT

The results secured from the use of the new chemical calcium cyanide for destroying chinch bugs at wheat harvest are given. Calcium cyanide did not prove practical when sown broadcast in infested wheat fields or when applied as a line barrier on the surface of the ground. In tests where it was applied in a narrow strip or trap crop between wheat and corn fields, it proved promising. However, best results were secured when the material was distributed in a narrow line in the bottom of a deep narrow furrow such as made with a plow. The furrow should have practically a vertical wall next to the crop to be protected and a line of the chemical placed at the foot of the vertical wall. One pound of calcium cyanide flakes to each sixty linear feet of furrow applied in the afternoon when heavy migration of bugs began, proved effective in destroying the bugs for the rest of the day. This requires about 22 pounds, costing four dollars a day for material used in a quarter of a mile of barrier.

The chinch bug is one of the few serious naturalized insect pests of field crops. A glance at the literature dealing with the chinch bug shows it to have been one of our earliest and most important insect scourges. The early writings of Riley, Walsh, Webster, Forbes and others abound with descriptions of chinch bug epidemics, the life history of the pest and methods of controlling it. In fact, a careful study of these early writings and most of the later articles on this insect leads one to wonder if the earlier workers actually left much for the present day entomologists to find out either as regards life cycle or control.

Who first observed the wintering habits of the pest and recommended winter burning of grass and other rubbish to destroy the hibernating adults? What important new discoveries or recommendations have we made recently on this phase of the subject? Likewise who first found that at wheat harvest, the pest by migrating to corn again exposed itself to flank attacks with barriers? Who first recommended the use of dust barriers, and who the chemical barriers? What new discoveries have we made along the line of barriers in the last thirty years? Some new chemicals have been developed and some improvements made along the line of methods, but when all is said and done we of the younger generation must frankly confess that we have closely followed the worn entomological paths. The senior author can say this frankly and without fear of offending any co-worker in the chinch bug field, where he himself has labored these many years.

These general remarks are meant neither as fault-finding nor as an apology, but rather as a challenge to the younger men. That the

earlier recommendations on chinch bug control have failed to properly control the pest in some localities in recent years is unquestioned. How much of this has been due to lack of cooperation on the part of the farmer, we shall not attempt to estimate. However, it is true that for the past several years this pest has continued to extract its annual toll in the corn belt. Our failure to hold the pest is either due to ineffective remedies or inability to get the farmers interested in applying them thoroly. In either case it seems wise that we attempt to find some new and more effective line of attacks. The psychology of something new against the chinch bug is not to be overlooked, when dealing with chinch bug afflicted farmers. This is especially true if the new recommendation proves both effective and practical.

With these general observations we shall proceed to briefly describe the use of calcium cyanide for the control of chinch bugs in Missouri. Much remains to be found out about this new chemical as an insecticide but we have gone far enough to feel sure that it will play an important part in future chinch bug campaigns.

Calcium Cyanide

Calcium cyanide unlike potassium and sodium cyanide is a comparatively new chemical. It has been used successfully for a few years as a fumigant in the tunnels of rodents. George E. Sanders was the first to take special note of this chemical as an insecticide and he interested others in testing it. Flint made some preliminary tests with the material on chinch bugs in the fall of 1922. During the summer of 1923 the material was used on chinch bugs in Indiana, Illinois, Missouri, Kansas and Oklahoma in an experimental way and also quite extensively in practical field control in Missouri.

Calcium cyanide reacts with atmospheric water vapor, giving off hydrocyanic acid gas that makes this new chemical valuable as a barrier to the migrating chinch bugs.

Tests on Rate of Emission of Gas

At the outset laboratory and field tests were made to determine the rate and duration of the emission of gas. The influence of moisture, temperature and wind were studied. In these preliminary experiments only adult bugs were available for use at Columbia, Missouri. In order to make field tests using the immature bugs, the junior author was sent to Oklahoma for several days work. The purpose of these tests was to arrive at some definite conclusions regarding dosage and method of laying down the chemical as a barrier before wheat harvest and chinch bug migration began.

Tests were made with the material dusted or sown broadcast in wheat, scattered along narrow strips, as a line on the surface of the ground, in furrows of different types and covered with dry dust. The powder, granules and flakes were all used.

Broadcasting in Wheat

Some of our first work dealt with the use of the material sown broadcast in the wheat. Varying doses of the granules and powder up to 60 pounds to the acre were used. Repeated tests with this later dosage of granules, even with a five to ten mile breeze gave an almost complete kill not only of the chinch bugs but also ground beetles, Colorado potato beetles, grasshoppers, wasps, bees, lady beetles, plant lice and other insects which became enveloped with the gas. The heavier doses also caused some leaf burning. The use of the material for broadcasting in wheat fields was abandoned as impractical, the acreage, dosage and difficulty of application prohibited its use.

Calcium Cyanide as a Barrier

From the beginning the use of the material as a barrier seemed the most logical. In the preliminary tests it was used in a narrow strip two or three feet wide, in a narrow line on the surface of the ground and in a ditch. Dosages were used varying from one half pound to four pounds to each 60 feet. The heavier dosages maintained a killing barrier much longer than the lighter ones. It was soon found that for a line barrier the coarser flakes gave off gas more slowly and therefore lasted longer than either the granules or the powder. Later barrier work, therefore, dealt mostly with the flakes and our final conclusions on dosage refer to flakes rather than granules or the powder.

Narrow Strip Barrier with Trap Crop

The use of the material in a narrow strip was not given a thoro test due to the fact that trap crops had not been planted for the purpose. Several opportunities for testing the material in strips of sorghum were offered and gave satisfactory results with as small an amount as 30 pounds to the acre. After making a few tests with varying dosages it was abandoned for the line barrier. However, with trap crops of cane or sudan grass planted about a month before harvest, we believe from our observations that it will prove practical.

Line Barriers

Our line barriers were made first, on the surface of the ground, second in trenches of varying depths and forms and third, tho only in a few tests, covered slightly with dry dust. It is desirable to keep a

death line of gas as long as possible and with the least effort and use of material. Hydrocyanic acid gas is of about the same weight as air and when there is no breeze to scatter it, it will hover over the line of flakes whether on the surface of the ground or in a furrow. However, at wheat harvest there is usually a great deal of wind so it is necessary that this be taken into account and guarded against as well as possible.

Line Barriers Applied on Surface of Ground

In our preliminary tests with the surface barriers we used from one half pound to four pounds of granular cyanide to sixty linear feet of barrier. The smaller dosage applied when there was a six-mile wind, killed adults bugs which attempted to cross, for only one hour. The heaviest dosage, applied under the same conditions, remained effective for from three to five hours and killed some bugs five feet from the line due to drifting of gas. These also burned the lower blades of wheat. A dosage of one pound to sixty linear feet of barrier on the surface of the ground remained effective for only about two hours on the average. The drifting of the gas from a surface barrier is too great for most effective results.

Line Barriers Applied in Furrows

Furrows may be made of various shapes and forms and our results show that a narrow, deep furrow gives far better results than do those of other types.

In our first tests we used a hoe and a hand plow to make a shallow ditch from one to three inches deep. This showed a decided improvement over the line on the surface of the ground due mostly to the fact that it retarded the progress of the bugs and kept them longer in the gas area. A very shallow ditch does not help materially in checking the drifting of the gas, but it will keep the bugs busy longer climbing out of the gas area.

A deep furrow made with a plow and rounded out with a post, was then used. This provides a definite container for the gas and where there is no breeze it should be expected to work well. However, in our tests it was found that a broad rounded-out furrow of this type allowed the gas to spread out in the furrow, and it permitted the wind to blow it out readily. The broad furrow in our tests gave no better results than a narrow shallow furrow made by hand. However, it does provide for the possibility of combining a mechanical barrier with the gas barrier.

To chinch bug workers it is a well known fact, that normally at harvest the bugs move mostly during a few hours of the day and only

light scattering movement occurs during the rest of the day. When the gas and mechanical barriers are combined the log, as in the ditch-log barrier, can be kept moving thruout the morning when but few bugs are moving, and then the gas barrier laid down in the afternoon when heavy movement starts.

However, Missouri farmers prefer either to fight all the time with the ditch-log or to use the gas alone. Only a few reported using the combined barriers.

In our tests the broad, rounded furrow with one pound of calcium cyanide to sixty feet remained effective for only two or three hours and did not prove entirely effective thruout the afternoon migration.

The type of furrow used most in Missouri was a plowed furrow with the dirt thrown toward the wheat stubble and the side next to the corn as nearly as possible a vertical wall. This is the type of furrow most farmers make and we have found it to be the most effective. This is probably due to the fact that it provides the best protection against the drifting of the gas and the concentrating of gas at the foot of the vertical wall. The vertical wall is also an effective barrier up which the bugs, already weakened by the gas, are unable to climb. In such a furrow one pound of calcium cyanide flakes to each sixty feet applied in the early afternoon proved effective in preventing bugs crossing for the rest of the day. This is the dosage and type of furrow and method of application which gave us best results this summer. Likewise, this is the type of barrier used by most of the farmers in the state. Our tests were made in different counties in the northern part of the state thruout the migration period. The migration was later than normal and more drawn out than usual which made the use of any type of barrier more difficult than under normal conditions. We believe, therefore, that in a normal season with a heavy active migration of bugs, the gas barrier would have worked more rapidly, cleaned up the bugs in fewer days and thus proven more effective and cheaper. Still our results last summer were highly satisfactory and the farmers using the material were pleased with their results as the following summary of their reports will show.

Sixty-five questionnaires were sent out to Missouri farmers, who used calcium cyanide for chinch bug control, and thirty-three replied. Of these, twenty used the material in a furrow and all reported success even tho four used less than one pound to sixty feet of barrier a day. Thirteen used other methods and all but one of these reported satisfactory results. Of those following directions only one considered the

material too expensive. This is further attested to by the fact that the Missouri Farmers Association, an independent organization of some 70,000 Missouri farmers have just recently contracted for a minimum of twenty tons for their 1924 chinch bug campaign.

Summary

(1) Calcium cyanide flakes used in a properly prepared furrow at the rate of one pound to sixty linear feet once a day proved an effective chinch bug barrier in Missouri. The material in such a barrier cost about four dollars a day for a fourth of a mile of barrier.

(2) For best results it should be applied in the early afternoon or when the daily migration begins.

(3) A narrow, deep furrow with a vertical wall next to the crop to be protected proved to be the best type of furrow in which to apply the calcium cyanide flakes.

(4) Other type of furrows or methods of applying the chemical did not prove so effective.

(5) Temperature, moisture and wind are factors influencing the success of such a barrier.

Question: What is the cost per mile of treating such a furrow?

Mr. Leonard Haseman: About $4 per day for a quarter mile. It depends upon the rapidity with which the gas cleans up the infestation. That really determines the total cost.

Mr. J. J. Davis: I want to make a brief statement regarding the use of calcium cyanide in controlling chinch bugs. The results obtained in Indiana are not sufficient to permit definite recommendations and I wish at this time simply to bring out the fact that we must look to cheaper calcium cyanide or more efficient methods of application to make its use practical under Indiana conditions. Mr. Haseman recommends it at the rate of one pound to 60 linear feet, which, at 18 cents a pound would cost $3.96 per quarter mile per day or $55.44 for material to treat a quarter mile furrow for 14 days, the minimum period of chinch bug migration. By using the creosote barriers, which Mr. Flint has found to be very effective in Illinois, and which we have also found to be effective in Indiana, the cost for material per quarter mile for the entire period of chinch bug migration is $6.00 or $7.00. The difference in cost is too great to consider calcium cyanide as a practical chinch bug control at the present time.

MR. J. A. HYSLOP: Mr. Haseman's statement in regard to broadcast treatment with calcium cyanide destroying the bugs, brought to my mind the statement of Mr. Turner, that the broadcasting treatment now being used in Georgia, for the weevil, made so extreme a change in the biological complex in the cotton fields, that the cotton aphis was very much more destructive in the fields treated than those not treated. I believe in these new, very extensive treatments that the Entomologists are using, that we will do well to consider the changes in the complex in relation to other insects than with which we are working.

The final business of the Association was then transacted and the meeting adjourned.

NEW DEVELOPMENTS IN ALFALFA WEEVIL ACTIVITY AND CONTROL

By CLAUDE WAKELAND, *Entomologist, Idaho Agricultural Experiment Station*

Investigational work was undertaken by the Idaho Agricultural Experiment Station this year to determine why spraying for the control of alfalfa weevil (*Phytonomus posticus* Gyll.) in southwestern Idaho had not proven so successful as elsewhere. The situation is of more than local interest because it shows the error of assuming that problems that have been successfully solved by research workers can be turned over to extension workers and forgotten.

Spraying for the control of this insect has been recommended generally as a practice proven by experiments conducted by the U. S. Bureau of Entomology (1) (3) and by the Colorado Experiment Station (2). It was found that one spray application reduced the injury to such an extent that little loss was sustained on the first crop and the second crop started growth immediately after the cutting of the first crop. This spray is applied at a time designated by Reeves and his co-workers as the "turning point of injury" (Fig. 8). This turning point is governed by the relative development of the weevil and its host plant and occurs close to the date when the greatest number of larvae are emerging, which usually is from one to three weeks before the date of cutting of the first crop. In Utah and Colorado the majority of the larvae usually emerge from the eggs at a rather definite time, which may be designated as the "height of the hatching season." Under conditions there, height of hatching season and turning point of injury are nearly analagous terms when considered in relation to the timing of spray applications.

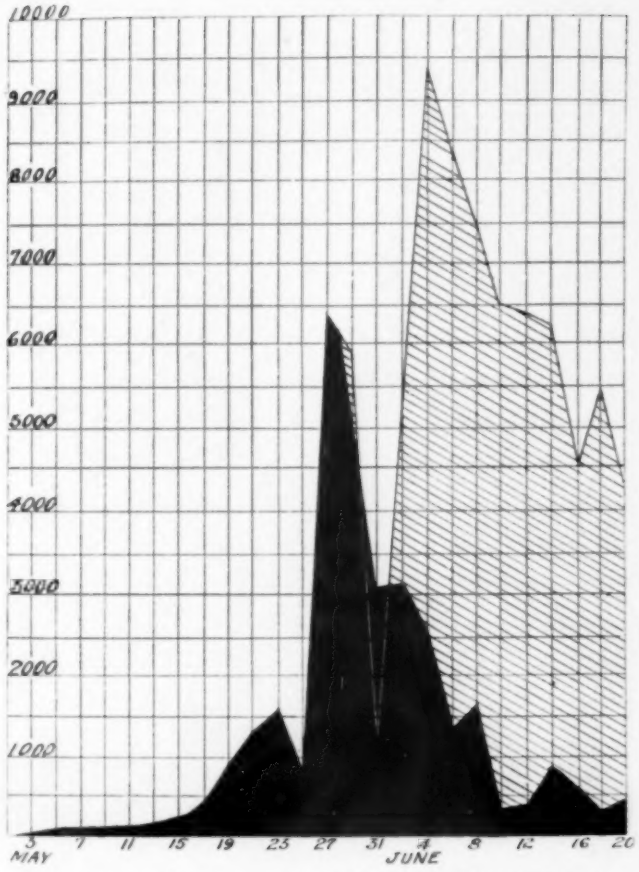

Fig. 8.—One spray application, western Colorado. Horizontal lines represent number of larvae collected in 100 sweeps of the net. Black area represents sprayed portion of field and cross-hatched area unsprayed portion. Sprayed May 27. Plots cut June 20. (Adapted from Eleventh Annual Report, Colo. State Entomologist).

Extension work conducted by the University of Idaho was for three years based on experimental results cited above. The spray was applied at the time of the turning point of injury which, roughly defined, was when larvae became so numerous in the alfalfa tips as to check the growth of the plants. The general plan of work was to conduct spray demonstrations starting in communities of earliest growth and proceeding, as the season advanced, to those of later development and higher elevations. A demonstration machine equipped for alfalfa

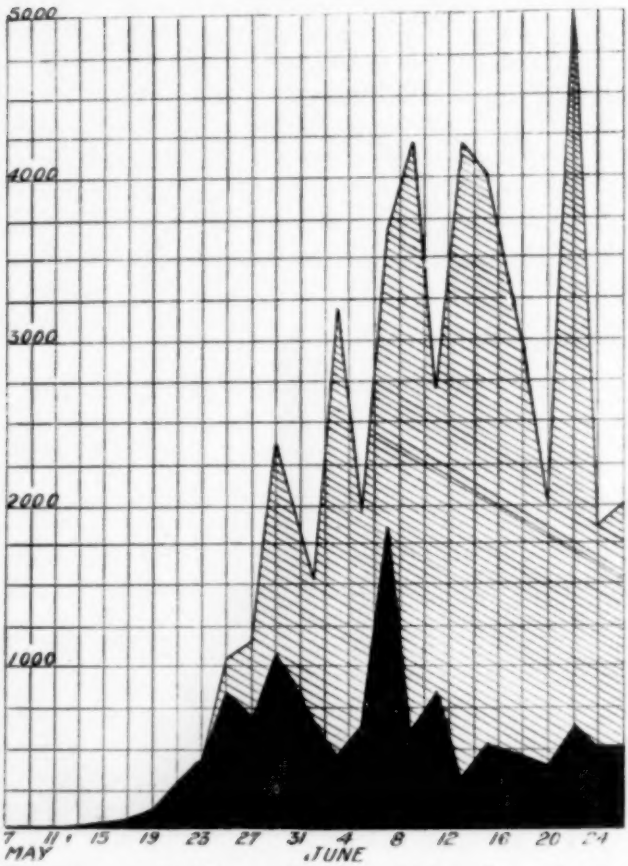

Fig. 9.—One-spray application, southwestern Idaho. Sprayed June 7, 1923. Plots cut June 27. Note the large numbers of early-season larvae on sprayed plot which were sufficient to cause serious injury.

spraying was transported on an auto truck. The difference in development of the weevil in different localities of the state is very favorable to a long demonstration season, and an effort was made to conduct as many demonstrations as possible during a season. Conditions that favored a long demonstration season were the ones also that made it impossible to observe results closely, and the entomologist was rarely enabled to return to a sprayed field in time to make observations of results obtained. Reports received from county agricultural agents and from farmers varied widely and were extremely confusing. Reports were that results in eastern Idaho were satisfactory. In the south-

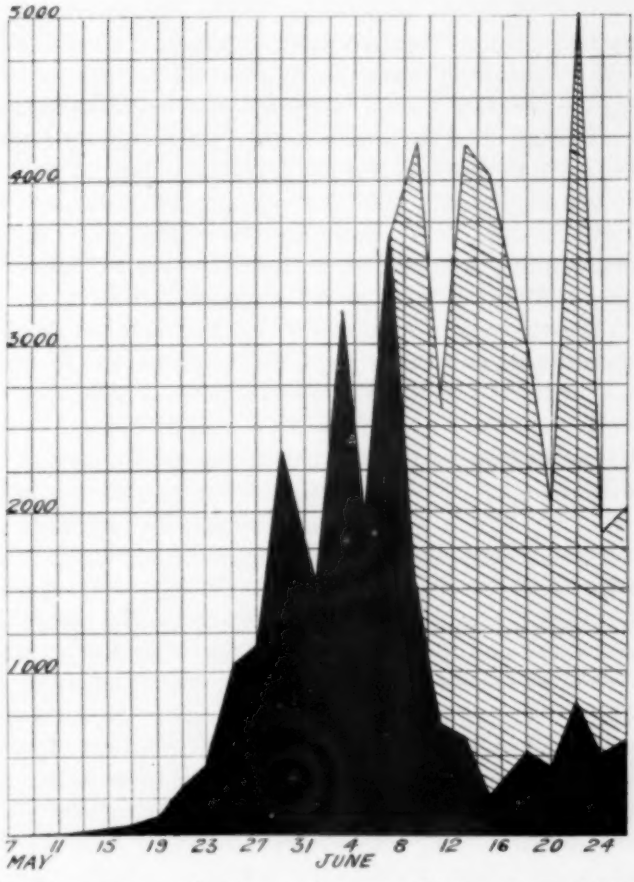

Fig. 10.—Two-spray application, southwestern Idaho. Sprayed May 24 and June 7. Plots cut June 27, 1923. Amount of injury on sprayed plot was slight compared with check. Note decrease of larvae on sprayed plot following each application and comparatively small proportion of early-season larvae.

western part of the state, however, the first reports following a demonstration were favorable, only to be followed by others that spraying had not proven successful. In several communities in that part of the state spraying had been tried by individuals, the knowledge that spraying by them and by the University had not proven successful had become common, and it is little wonder that others were loath to try it.

For experimental work in southwestern Idaho, which has probably proven to be the worst injured portion of the United States, a large field of alfalfa was selected in which growth and cultural conditions were as

nearly uniform as it was possible to obtain, and measured; one-acre plots were staked out. On each plot conditions of growth were noted throughout the period of development of all three crops for the season, and during the period of growth of the first crop larval counts were made each alternate day after the alfalfa became tall enough to sweep with a net. The fact that results in former years had appeared to be good for a time after spraying indicated that possibly an additional spray application was needed. This possibliity was supported by the fact that field examinations during the two previous years had disclosed large number of freshly deposited eggs in the stems after the spray had been applied. Among other experiments it was therefore determined to try applications of one and two sprays and to check the results of each against an untreated plot. For the purpose of this discussion no mention will be made of plots other than numbers 1, 3, 5 and 6.

Plat No. 1 was sprayed May 24th with calcium arsenate at the rate of two pounds per acre. A pressure of 225–250 pounds was maintained. On that date the alfalfa was a little less than knee high, and blossom buds were just plainly visible in the tips without careful inspection. Bud clusters were not separating and no color was showing in any of the buds. Larval injury was general over the entire plot, though not severe, and there was no noticeable checking of growth. Most of the larvae were large in size, some nearly full grown and rarely a cocoon was observed. It was a striking fact that injury that necessitated a spray was caused by early-hatched larvae, and that those representing the main part of the brood had not yet appeared, even in an early stage. (Fig. 9.) Observations on the check plot throughout the season showed that without spray little growth was made after the date mentioned above, altho the height of larval emergence did not come until 21 days later, so that a field that had been sprayed just preceeding this height would have been so severely injured as to not make recovery.

After spraying, the alfalfa on plot No. 1 grew almost normally for a time, and rapidly recovered from the previous injury. On June 6th it was noted, however, that the green growth had been made since spray was applied was being attacked and a second spray application was made on June 7th (Fig. 10). At that time the alfalfa was a little more than knee high, blossom buds were broadly separated and an occasional one showed the color of an opening blossom. The majority of the larvae at that time were small, were but recently emerged and represented a portion of the main brood. At cutting time this plot was about one-half in blossom; foliage was a green, healthy color and

showed very little injury. The second crop started immediately, altho a little ragged, and made a steady, rapid growth.

Plot No. 3 was sprayed but once, the date being June 7th. At that time the general appearance of the field was brownish and the foliage was severely injured. After spraying, it recovered gradually until at cutting time the predominant color of the tips was green, and there was a ragged sprinkling of bloom over the entire plot. The second crop was slow and irregular in starting. A striking contrast between plots one and three was in the greater number of pupae on the latter due to the transformation of early-emerged larvae before the application of poison.

Plot No. 5 was cut early, June 7th. A notion exists among some farmers that the alfalfa weevil can be controlled by cutting the first crop early before it is injured. On the date mentioned very little injury had occurred on this plot, and it was cut in accordance with this notion. Even tho the first crop was cut three weeks earlier than on Plot No. 1, the second crop was two weeks later starting, thus five weeks elapsed after the cutting of the first crop before second crop growth started. An important point in relation to the maintenance of an alfalfa stand is here involved. Without control a field heavily infested with alfalfa weevil cannot make second crop growth until such a time as a majority of the larvae have entered the pupal stage and ceased feeding. During this time foreign grasses and weeds have an opportunity to make a quick, unrestricted growth. This condition is usually aggravated by the farmer who thinks to stimulate his alfalfa to a rapid recovery by the free use of irrigation water. The infested alfalfa cannot respond and the grasses and weeds are given an almost ideal condition for establishment and growth. Plot No. 5 was almost entirely green with blue grass (*Poa pratensis*), water grass (*Echinochloa crus galli*), squirrel tail (*Hordeum jubatum*), and *Bromus tectorum* within a few days after cutting, and throughout the growth of the second crop these grasses were so tall as to hide almost completely the alfalfa. No attempt was made to weigh the second crop hay on this plot since there was no means of separating the alfalfa and weeds. After removal of third crop hay this plot showed a heavy stand of grass while the alfalfa stand in an adjoining sprayed plot was in a very good state of preservation. Other investigators have cited the undesirability of early cutting from a physiological standpoint.

Plot No. 6 was untreated and allowed to stand as a check until June 26th when it and all sprayed plots were cut. At that time there

were no blossoms on this plot, and the foliage was so severely eaten as to render the hay almost valueless. Growth was not resumed until three weeks later than on the sprayed field adjoining. Relative stages of development were maintained on all plots throughout the period of growth of the second crop which was cut August 15th.

HAY WEIGHTS

Plot No.	First Crop	Second Crop	Total
1	5957 lbs.	5313 lbs.	11270
5	4761 lbs.		
6	4799 lbs.	4135 lbs.	8934

All the first and second cutting hay on each plot was weighed with the exception of second crop hay on Plot No. 5 as noted above. Third crop hay was not weighed because of weather conditions unfavorable to obtaining accurate data.

COST OF TWO SPRAY APPLICATIONS PER YEAR AND SAVING RESULTING

It has been proven by practical field work that under average field conditions a traction spray machine will care for 200 acres of alfalfa per year, and that with average care a machine should operate satisfactorily for at least five years. On this basis the following calculations are made:

Cost of Spray machine complete with spray bar and filling pump	$300.00
Calcium arsenate for 1000 acres, 4 lbs., per acre per year for 5 years, 4000 lbs. @ 20 c.	800.00
Repairs for machine, estimated at $20.00 per year	100.00
Labor, man and team, 70 days, 14 days per year for 5 years, @ $6.00 per day	420.00
Total cost of spraying 1000 acres twice, 200 acres per year for 5 years	$1620.00
Cost of spraying one acre twice, or cost per year	$ 1.62

A fair valuation to the farmer for alfalfa hay in Idaho over a period of years is $8.00 per ton. From weight tabulations above it will be noted that the gain in hay per acre as a result of spraying was 2336 pounds. From these figures the net saving is derived:

Sale value 2336 pounds hay @ $8.00 per ton, or gross saving per acre	$9.34
Cost of spraying, per acre	1.62
Net saving from spraying, per acre	$7.72

The loss from weevil is often much greater than occurred this season on the experimental check plot, and saving from spraying is correspond-

ingly greater. Judging from chemical analyses and feeding tests that have been made in connection with previous experiments, the amount of arsenic contained on hay that has been sprayed twice at the rate of two pounds calcium arsenate per acre per application is so small that such hay may be fed to live stock with safety.

SUMMARY

Contrasting conditions in southwestern Idaho with those in the eastern part of the state and in the weevil-infested portions of Colorado and Utah, it has been ascertained that instead of a rapid rise in the numbers of larvae following a somewhat definite "peak" in egg hatching, there was in 1923 a prolonged period of hatching and no definite peak. The "turning point of injury" occurred some fourteen days before the heavy emergence of larvae began to take place. Larvae were present in almost equal numbers for a period of three weeks. The highest point of larval population did not occur until 28 days after the "turning point of injury." Under such conditions it has been determined that two sprays applied to the first crop of alfalfa are needed to afford protection from the alfalfa weevil. There are portions of the state where one spray is sufficient and there may be seasons where a second application will not be needed in southwestern Idaho, but the farmer must be prepared to use it if necessary. With the advance of the fanlfa weevil to still lower and warmer regions other adaptations of caotrol may be required.

REFERENCES

(1). U. S. D. A. Farmer's Bulletin 741.
(2). Eleventh Annual Report Colorado State Entomologist.
(3). U. S. D. A. Farmer's Bulletin 1185.

OBSERVATIONS ON AN OUTBREAK OF *UTETHEISA BELLA* L.

By M. T. SMULYAN AND R. T. WEBBER, *U. S. Bureau of Entomology, Melrose Highlands, Mass.*

The destructiveness of certain species of insects when transplanted from their native habitats to completely new habitats and the destructive activities in their native habitats of certain other species because of the modification of their environments (as through the introduction of new plants) is well known. The first category is well exemplified by such insects as the Gipsy Moth (*Porthetria dispar* L.) and the Japanese Beetle (*Popillia japonica* Newm.), the second by the Chinch-bug

(*Blissus leucopterus* Say) and the Colorado Potato-beetle (*Leptinotarsa decemlineata* Say). The degree and extent of the damage that certain native insects may inflict upon native and economically unimportant plants, however, is not so well known to entomologists, and some observations along that line, dealing with the apparent extinction of a local plant species and the relation of this to the behavior of the depredating insect in another respect is, therefore, worthy of record. The observations were made in Somerset County, New Jersey, where one or the other of the writers was engaged, during the summers of 1921, 1922 and 1923, upon insect parasite studies for the U. S. Bureau of Entomology.

The species of plant involved is the leguminous annual *Crotalaria sagittalis* L. (commonly known as Rattle-box) which ranges, chiefly along the coast, from eastern Massachusetts and southern Vermont to Florida and Texas, and northward in the Mississippi basin to Indiana and South Dakota (Gray, 1908). In Massachusetts, according to Professor M. L. Fernald of the Gray Herbarium, Harvard University, it is found invariably on sandy beaches of ponds, and in wet seasons may be "drowned out." In New Jersey, however, the stands or stations of the plant—those that were under observation at least—were in dry and open places quite removed from bodies of water and extended, respectively, over approximate areas of 5, 80 and 175 square rods.

The insect concerned was the Arctiid moth *Utetheisa bella* L., which occurs throughout the Atlantic States, in this country, and in parts of Canada, the larvae of which are reported by Packard (Fifth Rept., 1890) and by Smith (N. J. Insects, 1909) as feeding on cherry, elm, Myrica, Lespedeza and Crotalaria. The writers, however, have found the larvae only on *Crotalaria sagittalis*, although some of the other reported food plants were present in the localities.

The caterpillars were first observed July 20, 1922, and by August 19, about one month later, they were very numerous, as were also the moths. Some idea of the large numbers of larvae present may be had from the fact that although large numbers of them were collected between August 19 and 24, thousands were still present on the latter date, and as the Crotalaria was now exhausted, they were engaged in an apparently fruitless search for food. This condition obtained, roughly, in each of the three widely separated localities. In no instance, in the case of the food plant, as far as could be observed, did pod-formation and seed-setting take place. The following summer, that of 1923, no Crotalaria could be found on any of its three former sites. The insect

had thus literally wiped out, for the time being at least, a native and uncultivated plant species in three distinct localities.

The destruction of its food plant resulted, as might be expected, disastrously for the insect itself, and the behavior of the insect thus became interesting from another standpoint, namely, as illustrating the phenomenon of a remarkably sudden appearance and disappearance of large numbers of what appears to be a non-migratory insect. As the feeding of the larvae in 1921 was insufficient to attract attention, their numbers that summer must have been very insignificant. And none were found during the summer of 1923. The appearance, subsidence and complete passing of the insect may thus be said to have been contracted within the narrow limits of a single season.

It was the failure of its food supply that was responsible, as far as could be seen, for the extinction of the insect, as no disease apparently was present—none, certainly, in epidemic proportions—and the percentage of insect parasitism as indicated by the rearing of large numbers of the insect was very small.

THE EFFECTIVENESS OF CALCIUM CYANIDE IN THE EXTERMINATION OF THE BLACK TAIL PRAIRIE DOG, *CYNOMYS LUDOVICIANUS* (ORD.)

By Otis Wade, *University of Missouri*

Abstract

The efficiency of calcium cyanide as a control for prairie dogs was tested in 1922 and 1923 in Kansas. The flake form of the chemical was used in dosages of ¾, 1, 1½, and 2 ounces. The material was placed in each burrow entrance from 1 to 2 feet below the rim.

In three "dog towns" doses of 1, 1½, and 2 ounces were used and all entrances to dens closed. Total kills resulted in each instance. Eight infested areas were treated with ¾, 1, and 1½ ounce doses and all burrow entrances left open. In the two tests with 1½ ounce doses total kills were obtained. Complete extermination resulted in one test with 1 ounce doses. In the remaining five tests where doses of ¾ to 1 ounce were used, the effectiveness varied from 90 to 99 per cent.

The killing power of the chemical in open burrows in an important factor, since the closing of burrows involves considerable time and labor.

Preliminary tests by Professor F. L. Hisaw, Kansas State Agricultural College, indicate that calcium cyanide might be effectively used in the eradication of the pocket gopher, *Geomys bursarius* (Shaw). Doses of 1 and 2 ounces were used. The dose was placed in the main run through an opening made with a trowel. After dosing the holes were closed. Effectiveness varied from 88 to 94 per cent.

The use of calcium cyanide for the destruction of rodents was noted in a report by Professor George E .Sanders of Nova Scotia in 1921. In

his experiments the material was used with success in the control of a species of ground squirrel commonly referred to in that region as a "gopher."

Since calcium cyanide is receiving considerable publicity and is being strongly recommended by some as an efficient control for various noxious rodents, it seems desirable to report the results obtained with this material in tests made on the prairie dog in Kansas. These tests for the control of prairie dogs were made by the writer in May and August 1922 and April 1923.

The flake form of calcium cyanide was used throughout these experiments. The doses were placed down in the burrow entrances from one to two feet from the rim.

Except in three tests, all entrances to the burrows were left open after the calcium cyanide had been administered. This was done because it was thought if the material did not prove effective without closing all entrances, which is a slow laborious process, it would not be superior to methods already in use and it was the labor and attendant cost we wished to eliminate if possible.

The following data give the results of the first experiment:

Date	Area	Dosage	Entrances	Results
May 4, 1922	40 burrows	2 ounces	Closed	Total kill
May 5, 1922	58 "	1½ "	"	" "
May 5, 1922	157 "	1 "	"	" "
May 5, 1922	107 "	1½ "	Open	" "

Several inspections of the treated areas were made in May and June and a final inspection July 20. Not a living prairie dog could be discovered. A number of dead burrowing owls were noted in the entrances of open dens.

The second experiment was conducted August 3 with the following results.

Date	Area	Dosage	Entrances	Results
Aug. 3, 1922	88 Burrows	¾ to 1 ounce	Open	About 98% kill
Aug. 3, 1922	64 "	1½ ounce	"	Total kill

August 4 in the area treated with the smaller dose, three live dogs were seen and fresh work around the entrances of two dens was observed. The supply of calcium cyanide being exhausted these two live burrows were treated with heavy doses of carbon bisulfide to insure the death of the inmates. In the second town where more than one hundred prairie dogs were seen the previous day, there was no sign of life and the town appeared deserted. Eight dead burrowing owls were found

in open entrances, three being taken from one burrow. They had evidently gone in the evening after the treatment, which was about 5:00 P. M. and were overcome by the gas, indicating that the effectiveness of the gas is maintained for several hours after the flakes are placed in the burrow entrances.

August 29 the two dog towns were again visited and no live prairie dogs were seen and no signs of fresh work observed about any of the dens. The dogs were completely exterminated.

A survey of the results obtained in 1922 showed satisfactory kills, where entrances to dens were left open, with dosages of 1 to 1½ ounces per burrow. In the two tests made, May 5 and August 3 with 1½ ounces of calcium cyanide to the burrow, total kills were obtained and the other tests made August 3 with ¾ to 1 ounce to the dose was very promising with a kill approaching totality. In view of these results it was decided to continue the work in 1923 with a series of tests using a straight dosage of 1 ounce per burrow, in order to learn if this apparently minimum dose would be entirely effective.

Date	Area	Dosage	Entrance
April 10, 1923	107 burrows	1 ounce	Open
April 10, 1923	250–300 burrows	1 ounce	Open

On April 14 one live dog and fresh signs around five or six dens were noted in the smaller town; in the second town no dogs were observed but there was some sign of their activities, and the owner of the farm said he had seen two dogs the day before. The kill in this experiment was considered to be about 99%.

Another experiment was made as follows:

Date	Area	Dosage	Entrance
April 12, 1923	48 burrows	1 ounce	Open
April 12, 1923	253 "	1 "	"
April 12, 1923	271 "	1 "	"

At the time these towns were treated many of the females were suckling young but as yet the young apparently were too small to leave their nests since none were seen above ground. On May 19 all three dog towns were checked. In the first town no dogs or signs could be seen which indicated a total kill; in the second town three or four old dogs were in evidence and a number of young; in the third town a number of old dogs were seen with a fair sized population of emaciated looking young crawling about in search of food. It was concluded that, at the time the burrows were treated, some of the young must have been about ready to leave their nests but did not, until forced by starva-

tion to do so, when the gas was no longer effective. The percentage of kill was estimated at 90% to 100% in these three towns.

Preliminary tests by Professor F. L. Hisaw, Kansas State Agricultural Experiment Station, indicate that calcium cyanide might be effectively used in the eradication of the pocket gopher. Doses of one and two ounces were used. The dose was placed in the main run through an opening made with a trowel. These holes were always closed after the dosage was administered. In these tests only isolated runs were used and only one dose was put in a run.

Calcium Cyanide dust was tried out in a few holes but proved not to have any advantage over the flakes. One hundred holes were given two ounce doses. In ninety-four of these successful kills were made, or about 94% effective. In 187 holes a one ounce dose was used. Of these, 21 holes were later found to be plugged indicating that the gopher was not killed. In the remaining 166 the treatment was successful, giving a killing percentage of about 88%. Professor Hisaw feels that the holes plugged were for the most part done before gas could be generated from the flakes. He found that his best results were obtained in the spring when the soil was moist, while his poorest results were in the fall when the ground was dry. From this he concludes that the gas generation depends on moisture in the soil. He was able to detect the gas in the run 15 feet from the opening but no quantitative tests were made.

These tests in the destruction of pocket gophers are preliminary and further work is necessary before safe conclusions can be made as to effectiveness under various conditions and the proper dosages to use.

Conclusions

Calcium cyanide when used at the rate of 1 ounce to each burrow was 90% effective or better. When used at the rate of 1½–2 ounces total kills were obtained.

The burrows need not be closed, thus making an appreciable saving in time and labor.

The moisture in the air liberates hydrocyanic acid gas which remains in the burrow for several hours diffusing in all directions. The prairie dogs are killed in their attempt to come through this curtain of toxic gas, very small amounts proving fatal.

Temperature apparently is not a limiting factor in the use of calcium cyanide providing the inmates of the burrows are active.

Preliminary experiments indicate that calcium cyanide may also be used for the destruction of pocket gophers.

Scientific Notes

Blister Beetle—Serious Pests in Northern Arizona. Serious infestations of blister beetles during the past two years have made potato raising an uncertain problem in Chino Valley and on farms near Prescott. This being a comparatively new farming region and a tract of ground only recently opened up, it is evident that the beetles are migrating from the native vegetation. As two of the beetles have not heretofor been reported from Arizona, the following notations are of interest.

Macrobasis longicollis Lec.—On July 18, 1922 in Chino Valley these insects were found traveling in swarms and completely defoliating small potato fields. There were considerable areas where even the stems were cut to within four inches of the ground. By August 10, 1922 the swarms had scattered and the beetles could only be seen here and there on fields that had escaped the earlier infestation. In the summer of 1923 they again appeared in numbers.

Epicauta corvina Lec.—Approximately a month after the visitation of *Macrobasis longicollis*, this species put in its appearance in the same locality. These did not travel in swarms but could be seen running in all directions over the fields, along the ditch banks and across roads. They did not concentrate on the potato fields alone since their native food, the puncture plant (*Tribulus terrestris*), was growing abundantly on the waste ground and along the road sides. The insects were feeding on the potato plants and the weeds in about equal numbers.

Epicauta pardola Lec.—In June 1922 these blister beetles were found in great swarms feeding on alfalfa and potatoes in Skull Valley. The beetles were so numerous that from a little distance the alfalfa appeared blue as though it were in full blossom. In some instances as many as fifty beetles could be found on a single plant. They feed on the most tender leaves and buds, necessitating an early cutting of the crop.

In general the spraying with arsenate of lead has been done after the insects began their attack and this is generally too late in the case of *Macrobasis longicollis*, as the insects are capable of defoliating large areas in a few hours. The spray applied at the first appearance of the beetles killed large numbers, but not before evident damage had been done. In the case of *Epicauta corvina* it was used with a greater degree of success.

HAROLD R. BRISLEY, *Plant Pathologist, United Verde Extension Mining Co., Clemenceau, Arizona*

Toxicity of Sodium Fluoride to Man. The growing use in the home of sodium fluoride against roaches and as a repellent for ants emphasizes the need of definite knowledge of its toxicological principles. Sollman's "Pharmacology" states that "Fluorides have a very strong local irritant action. Their systemic action resembles that of oxalic acid and is probably produced in the same manner by the formation of insoluble calcium salts.". In a recent paper (Jour. of Pharmacology and Experimental Theropeutics, vol. 17 (1921), p. 197) the same author states that "Small doses of soluble fluorin preparations, even to one miligram per kilogram (0.06 of a gram for a 160-pound man) of weight are toxic and should be absent from the food of man and animals." The symptoms of poisoning from the fluoride iron are muscular weakness, difficulty of breathing, low blood pressure and inflammation of the entire alimentary canal."

A recent article in the Journal of the American Medical Association (Pittsburg) vol. 64, p. 1985, states that, "the toxic effects of the fluoride ion is similar to the oxalate ion. Intravenous injections of a dog in dosages ranging from 0.05 to 0.1 of sodium fluoride per kilogram of weight were fatal. The Massachusetts State Board of Health Monthly Bulletin (vol. 6, pp. 341–343) reports one death and several cases of poisoning from the mistaken use of insect powders, containing sodium fluoride. Several samples were anaylzed and found to contain from 16 to 62 per cent of sodium fluoride, but bore no poison label. The Journal Pharm. Chem. (vol. 21 (1920), pp. 5–8) gives a record of the poisoning of seven persons who had partaken of pastry, in the preparation of which sodium fluoride was by mistake used instead of bicarbonate of soda. The amount taken by each individual ranged from 0.228 to 0.456 gm. Nausea and vomiting followed, the attack lasting from three to twelve hours, followed by 36 hours of weakness. The giving of milk aided in recovery. Calcium lactate or other soluble calcium salts may be given as an antidote, —dosage 1 gm. (15 grains) or a few spoonsful of lime water may be substituted.

E. R. DeOng, *University of California*

Acarapis woodi **in Czecho-slovakia.** Since the discovery of *Acarapis woodi* by Rennie in 1920 in connection with the Isle of Wight disease, observations have been made in several countries on this species. The species is given by Rennie and his associates as the cause of the above mentioned disease of adult honeybees, and this opinion is generally accepted, this being the first definitely recorded case of a mite being pathogenic on an insect. In Switzerland, Morgenthaler found this species, or one which can not be distinguished from it, on the outside of honeybees that had died during the winter, no evidence of disease having been noted previously. Since that time, however, a number of instances of disease of adult bees have been located in French Switzerland, in which cases the tracheae of the diseased bees were filled with this species of mite. The pertinent literature on this subject is recorded in U. S. Dept. of Agric. Circulars 218 and 287.

Last May a letter was received from Rev. Ivan F. Kitzberger, editor of a leading bee-journal in Prague, stating that *Acarapis woodi* had been found in Czecho-slovakia (see pp. 21–22, Circ. 287), the identification having been made by Mr. Ctibor Blattný, a specialist on mites located at the Zoological Institute, Prague. Several other species of mites, both larvae and adults, were identified from material collected on combs which had been removed from the hives for some time. The Isle of Wight disease seems to be unknown in Czecho-slovakia.

An inquiry to Rev. Mr. Kitzberger for more information brings some rather important and most interesting reports from him and also directly from Mr. Blattný-Kitzberger reports in a letter dated December 28, 1923, that *Acarapis woodi* was found living free on empty combs (containing pollen) which had not been in a colony of bees for at least a year. These had been stored in a moist cellar but for three or four months had been placed in a warmer, dry room. In a personal interview with Mr. Kitzberger in January 1924, Mr. Willis J. Nolan, of this laboratory, learned that in all ten specimens of Acarapis were thus located. These combs were somewhat infested with the greater wax moth also. In a letter dated October 24, 1923, Mr. Blattný states that in his opinion *Acarapis woodi* is normally a saprophyte, which perhaps because of some change in environmental conditions has in some cases become parasitic.

With these two letters there came a microscopic slide on which was mounted the

mite which Blattný had identified as Acarapis. This has been examined by Dr. H. E. Ewing, who states that it is beyond question an adult female of *Acarapis woodi*.

It is not the purpose of this note to make any interpretation of these findings but merely to bring them to the attention of interested persons in this country, thus paying a slight tribute to the scientific work now being undertaken along beekeeping lines in this new European republic. One can not, however, avoid mention of the fact that there is still much to learn regarding the interrelationship of Acarapis and the bee and that the cause of the Isle of Wight disease is still a problem worthy of attention. This does not in any degree indicate a reduction of the loss from this disease, nor justify any relaxation in preventing its introduction into America.

E. F. PHILLIPS, *Bureau of Entomology*

Thrips on Box Elder. About the middle of August, 1922, in passing through Box Elder County, Utah, I observed a very conspicuous discoloration of the leaves of Box Elder trees, especially within the limits of Willard. The most seriously affected leaves were generally high in the trees or at the end of long shoots. The discoloration was silvery and many trees were badly affected throughout—even partially defoliated. In Salt Lake County the condition was much less prevalent but quite common, especially near Magna. In 1923 the injury appeared again in Salt Lake County and was also noted near Prescott, Arizona. The causative agent is a small brownish thrips. Specimens sent to Mr. J. D. Hood have been provisionally referred to *Scirtothrips citri*.

WYATT W. JONES

JOURNAL OF ECONOMIC ENTOMOLOGY

OFFICIAL ORGAN AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

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The editors will thankfully receive news matter and other items likely to be of interest to our readers. Papers will be published as far as possible in the order of reception, except that papers of reasonable length may be accepted in the discretion of the editor for early publication, at $3.00 per page for all matter in excess of six printed pages; in the case of other matter, the maximum of 2,500 words is still operative. Photo-engravings may be obtained by authors at cost.

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The symposium on estimating the abundance of insects opens up a wide field in relation to entomological statistics and reveals considerable diversity of method. There is little question but that injuries caused by insects are greatly underestimated as a rule and the benefits resulting from judicious control measures are very rarely fully appreciated. There is a marked difference between the percentage loss in the crop and the financial loss resulting from insect operations—market conditions very materially affect the latter. Economic entomology, before it is fully appreciated, must evaluate itself with a reasonable degree of accuracy, therefore the estimating of the abundance of insects and the losses from pest depredations have a greater practical value than appears at first sight. There is a weak link in the chain of circumstances which permits the repeated halving of estimates made by experts and the publication as actual losses of figures one-eighth the size of the original estimates. It would seem from subsequent developments that the experts were nearly right and that there was need of educating those responsible for the reductions. A well developed and comprehensive method of estimating would have gone far toward remedying the condition, and there is no question but that we are progressing in this direction. The problem is really a very complicated one and present methods can not be scrutinized too closely in order to avoid everything of a doubtful or misleading nature in regard to our estimates. They should represent, so far as may be, an accurate picture of conditions and

should be stated in such terms as to be comparable for different sections of the country and over a series of years. It would seem that as a general rule, the proportion of plants, fruits, etc., and the proportionate injury to such would the most reliable standard, supplemented in some, possibly many, cases by statements of the estimated financial losses. The latter are valuable even though they are materially affected by market conditions. There is little need of the economic entomologist magnifying insect losses. One of his chief problems is to present a clear picture of what insect depredations actually mean and through this presentation convince the public of the economic justification of such control measures as may be advocated.

Current Notes

Mr. C. H. Popenoe of the Silver Spring laboratory, Bureau of Entomology, is taking special work at the University of Maryland.

Mr. W. V. Tower, Entomologist of the Federal Experiment Station in Porto Rico, has resigned to accept a position with a Porto Rican tobacco company.

According to *Entomological News*, Mr. Edwin A. Bischoff, a coleopterist of Newark, N. J., died December 23, 1923, in the 58th year of his age.

Professor W. C. O'Kane of the University of New Hampshire spent a couple of days at Iowa State College, Ames, Iowa, during the fore part of January.

Dr. Herbert Osborn lectured before the classes in Entomology at the University of Tennessee during the first week in January. Dr. Osborn was tendered a banquet by students and faculty members during his stay in Knoxville.

Doctor Alexander D. MacGillivray, Professor of Entomology at the University of Illinois, died suddenly of heart failure at his home in Urbana early on the morning of March 24. He leaves a widow and two sons.

Col. Clarence Ousely, formerly Assistant Secretary of Agriculture, has been engaged by the New Orleans Boll Weevil Control Association as Secretary and Manager of Activities.

Mr. K. C. Sullivan, Assistant Professor of Entomology, University of Missouri, will pursue graduate work in the Entomology Department, Cornell University, during the summer term.

Mr. Stefan Keler is now Forest Entomologist of Poland, and his address has recently been changed from 22 Nabielaka, Lwow, to: Bydgoszcz, Panstwowy Instytut Naukowo-Rolniczy, Wydziat Chorob Roslin, Poland.

Mr. Barton C. Ressler, a graduate assistant in Zoology and Entomology at Iowa State College, Ames, Iowa, has accepted a position as Assistant Professor of Zoology at the University of Tennessee.

Mr. T. H. Jones, for many years a collaborator of the Bureau of Entomology, truck crop insect investigations, has been appointed to a position in the gipsy moth investigations of the Bureau.

According to *Science*, Mr. E. Ballard has resigned his post as lecturer in entomology in the University of Bristol on his appointment as entomologist to the Empire Cotton Growing Association in Queensland.

Mr. T. C. Barber, Bureau of Entomology, has returned from a trip into Mexico. He reports finding several new parasites of the sugar-cane moth borer, one of which seems to be very efficient.

According to *Entomological News*, the Honorable N. C. Rothschild a well-known British entomologist, died October 12, 1923. His splendid collection of Siphonaptera, with an endowment of ten thousand pounds was willed to the British Museum.

According to *Science*, the New York State Agricultural Experiment Station has leased from Vassar College a building which is to be used for special research in entomology and plant pathology in the Hudson River Valley.

Mr. N. E. Winters, in charge of the cooperative boll weevil investigations of this Bureau and the South Carolina Agricultural Experiment Station, at Florence, S. C., has resigned, effective January 31, 1924, to accept a position in Argentina.

Mr. O. C. McBride, Instructor of Entomology, University of Missouri, has resigned to accept a position of Instructor of Entomology in the University of Minnesota where he will devote his time exclusively to research work on insecticides.

Mr. G. P. Walker of the Entomological Branch, Canadian Department of Agriculture, delivered a series of entomological lectures at the short courses held during the latter part of the year at the newly established Agricultural School at Fredericton.

According to *Science*, Mr. Harold Tappin goes in the capacity of Assistant Entomologist with the eighth expedition of the Department of Tropical Research of the New York Zoological Society, which left on February 11 for Georgetown, British Guiana.

Mr. J. R. Parker, Associate Entomologist in the Experiment Station at Montana State College, returned in February from an absence for study at the University of Minnesota, where he has been pursuing work for the degree of Doctor of Philosophy.

Dr. J. D. Tothill and family left Fredericton on February 15 for a vacation in England. While in London, Dr. Tothill will spend several days examining and redescribing the Walker types of North American Tachinidae in the British Museum Collection.

The following entomologists visited Washington on February 8 to attend conferences and hearings: W. C. O'Kane, Durham, N. H.; W. E. Britton, New Haven, Conn.; T. J. Headlee, New Brunswick, N. J.; H. L. McIntyre, Albany, N. Y.; C. H. Hadley, Harrisburg, Pa.; E. N. Cory, College Park, Md.

Professor Neguib Iskander, Assistant Entomologist of the Ministry of Agriculture of Egypt, recently visited the Bureau of Entomology and some of its field stations to study fumigation methods, especially those used in the control of the insect enemies of citrus fruits.

At the annual meeting of the Board of Governors of the Crop Protection Institute, held at the Chemists Club, New York City, February 14, the following entomologists were present: E. D. Ball, W. E. Britton, G. A. Dean, M. D. Leonard, W. C. O'Kane, P. J. Parrott, and A. Peterson.

Realizing the economic importance of farm birds in the control of insect pests, the Department of Entomology in the University of Missouri is offering a regular department course dealing with the study of birds and their value in the control of insect pests.

Dr. Philip Luginbill of the U. S. Bureau of Entomology received the Ph.D. degree at the George Washington University at its winter convocation on February 22. Dr. Luginbill is in charge of the Cereal and Forage Insect Laboratory of the Federal Bureau at Columbia, S. C.

Mr. E. Graywood Smyth, Special Field Agent, connected with truck crop insect investigations, Bureau of Entomology, for more than a year and a half, most of which time he spent in Mexico investigating parasites and natural enemies of the Mexican bean beetle, has returned to New York, having completed the temporary special work for which he was engaged.

Mr. T. E. Holloway, Bureau of Entomology, attended the annual meeting of the inspectors of the Mississippi Plant Board at Starkville, Miss., during December, and at the request of Professor Harned, gave brief talks on the sugar-cane moth borer and its control in Mississippi, and on miscellaneous sugar-cane insects.

Professor W. C. O'Kane gave an address on "Some New Facts About the Control of Nursery Pests" before the thirteenth annual meeting of the New England Nurserymen's Association, Boston, Mass., January 30, and at a tree worker's institute at New Haven, Conn., March 11 on "Some Insects Attacking Shade Trees."

Messrs. C. H. Popenoe, Sligo, Md., and J. E. Dudley, Jr., Madison, Wis., of the Bureau of Entomology attended the National Canner's Convention at Buffalo, N. Y., January 21–26. Mr. Dudley presented a paper on the control of the pea aphis and Mr. Popenoe had charge of an exhibit made by the Bureau.

The U. S. National Museum has recently temporarily assigned an additional room for use of the Bureau of Entomology, and the National Collection of Coccidae has been moved into it. Mr. Harold E. Morrison and staff will also occupy this room. Formerly this collection was housed in the Insectary of the Bureau.

Mr. E. A. McGregor, who was connected with the Bureau of Entomology for a number of years, has been reappointed and assigned to duty at Lindsay, Calif., where he will continue the field operations under way against the citrus thrips, work which was formerly conducted by A. J. Flebut, who recently resigned from the service.

A conference of field foremen engaged in gipsy moth work in New York and western New England was held at Albany, N. Y., January 17 and 18. This meeting was addressed by H. L. McIntyre who presided, A. F. Burgess, Melrose Highlands, Mass., W. E. Britton, New Haven, Conn., Drs. E. P. Felt and M. D. Leonard, Albany, N. Y.

Dr. Andrew Balfour, formerly Director of the Wellcome Research Laboratory, Khartum, Anglo-Egyptian Sudan, who worked for many years on medical entomology, especially sleeping sickness, and Colonel F. F. Russell, General Director of the International Health Board of the Rockefeller Foundation, New York, visited the Bureau of Entomology recently. They also viewed the insect collections in the United States National Museum.

On February 6, 7 and 8, Mr. Arthur Gibson, Dominion Entomologist of Canada, presided over a conference of Federal and Provincial game officials called by the Dominion Parks Branch of the Department of the Interior. This conference was attended by representatives of the various provinces interested in the conservation of wild life. It was held in the House of Commons at Ottawa.

According to *Science*, Messrs. Theodore R. Garner and Harold A. Jaynes of the Bureau of Entomology, planned to sail on March 4 from San Francisco for Kobé, Japan, to carry on research work in parasitology, with special reference to the Japanese beetle (*Popillia japonica*). After a year in Japan and Korea, they expect to continue for several years the study of allied parasites in China and India.

Mr. L. S. McLaine returned to Ottawa on January 7th, after spending his holiday[s] in New York. During his absence he visited the headquarters of the Federal Horticultural Board in that city and through the courtesy of Mr. H. B. Shaw, in charge of the work, went into the system of handling permits, inspections, etc. Mr. McLaine also spent a day with the offiicals of the Federal Horticultural Board in Washington, D. C.

Professor Herbert Osborn of the Ohio State University visited the Sugar-Cane Insect Laboratory at New Orleans and took part in a conference on the control of the sugar-cane moth borer. Others at the conference were W. G. Taggart, director of the Sugar Experiment Station, Ed. Foster of the Nursery Inspection Service, W. G. Bradley, Entomologist of the Louisiana Stations, and T. E. Holloway and W. E. Haley of the Bureau of Entomology.

Recent visitors to the U. S. National Museum include: Mr. Henry Bird, Rye, N. Y.; Dr. M. D. Leonard, Albany, N. Y.: Dr. S. J. Hunter, Lawrence, Kan.; Mr. Arthur Gibson, Dominion Entomologist, Ottawa, Can.; Mr. A. J. Mutchler, American Museum of Natural History, New York City; Mr. M. C. Van Duzee, Buffalo, N. Y.; Mr. A. E. Miller, Wooster, Ohio, Mr. R. E. Tarbett, Texas; and Dr. Andrew Balfour, formerly Director of the Wellcome Research Laboratory, Khartum.

In the recent earthquake and fire in Japan, Dr. Inokichi Kuwana, the Director of the Imperial Plant Quarantine Station at Yokohama and the best known of the Japanese Economic Entomologists, lost his entire library and collection, together with the complete edition of a work upon Entomology which had just been published. The Doctor is, therefore, in great need of economic literature. Any such works which the economic entomological workers in this country could send him would in consequence be most welcome.

The following men of the division of cereal and forage insect investigations, Bureau of Entomology, are taking graduate work: W. H. Larrimer at Ohio State University, G. W. Barber at Harvard University, H. L. Sweetman at Iowa State University E. J. Udine at Montana State College. The following are planning to take work: W. J. Phillips at the University of Virginia, D. W. Jones and K. W. Babcock at Harvard University, F. W. Poos at Ohio State University, L. H. Patch at Massachusetts Agricultural College, and C. M. Packard at the University of California.

Entomologists of Ohio, Indiana, Illinois, Missouri, Kansas, Iowa, Minnesota, and Wisconsin, planned to meet in Columbus, March 6 and 7. The association

includes Federal entomologists located in the district as well as all state entomologists. The problems common to the section will be discussed and projects planned to cover all without needless duplication. Entomologists of Michigan and Kentucky have been invited to this conference because of their peculiar interests in the European corn borer and Mexican bean beetle, both of which are advancing into the district.

Mr. H. B. Peirson has recently been appointed Entomologist in the Forest Service, under the technical direction of the division of Forest Insect Investigations, utilizing cooperative funds supplied by Maine timberland owners. For several years Mr. Peirson has been serving as State Forest Entomologist in Maine under the direction of the State Forest Service, supported by the timberland owners. The present arrangement will make it possible for him to maintain closer relations with the Northeastern Forest Service Experiment Station and Represent the Bureau of Entomology in cooperative work at that station.

The Rhode Island Nurserymen's Association held a well attended meeting on February 6 at which there was a spirited discussion on various subjects relating to the nursery business, and particularly with regard to the operation of quarantines against New England because of the presence of the gipsy moth. The afternoon was devoted to a program consisting of : "Rose Growing for Nurserymen," by W. E. Craig of Massachusetts; "Propagating Evergreens," by H. H. DeWildt; and "New Insects of a Serious Nature Recently Introduced or Likely to Come into Rhode Island from Other States," by A. E. Stene.

The following State Entomologists visited Washington to attend the Japanese beetle hearing of the Federal Horticultural Board, January 4, 1924; George G. Becker, Little Rock, Ark.; E. N. Cory, College Park, Md.; S. B. Fracker, Madison, Wis.; P. A. Glenn, Urbana, Ill.; C. H. Hadley, Harrisburg, Pa.; T. J. Headlee, New Brunswick, N. J.; S. J. Hunter, Lawrence, Kans.; M. D. Leonard, Albany, N. Y.; and Frank N. Wallace, Indianapolis, Ind. The following also attended: Arthur Gisbon, Dominion Entomologist, Ottawa, Canada; L. S. McLaine, Chief, Division of Foreign Pests Suppression, Ottawa, Canada; Wilmon Newell, Plant Commissioner, State Plant Board, Gainesville, Fla.; and C. A. McCue, Director. Agricultural Experiment Station, University of Delaware, Newark, Del.

The Entomology Department at Montana State College has moved into its new quarters in Lewis Hall. The new structure is a five story building 135 by 65 feet, and is devoted entirely to the biological group of subjects, including the departments of Botany, Entomology and Zoology. The Entomology Department will have four laboratories for Experiment Station work, an insect collection room, an insecticide laboratory, an artists' room, photographic laboratories, offices and library. There are two student laboratories for entomology and two lecture rooms. The equipment includes also a refrigerating plant and temperature conditioning chambers. There are also laboratories and offices for beekeeping and rodent control.

An agreement has recently been signed by which the Bureau of Entomology, the University of Minnesota, and the Lake States Forest Experiment Station will work together in more extensive investigations of forest insects in the Lake States as a basis for their control. The investigations shall be planned, approved, and conducted jointly by the three parties to the agreement. With the precedent of the

enormous damage done to the tamarack by the larch sawfly and to the spruce and fir by the spruce bud worm and the recent appearance of serious infestations of the jack pine sawfly which threatens to wipe out forests of that species in the region, this start in a cooperative attack on the problems involved is most opportune.

On account of favorable weather conditions and the fact that several of the districts which were important breeding centers in the past were found to be clear of infestation by the brown-tail moth, the work in Nova Scotia this season has progressed much faster than usual. Up to February 2, only 57 nests had been found which is the smallest number collected in Nova Scotia since the work was first undertaken in 1907. The majority of the nests this year were taken at Bridgetown which locality has been an important breeding center for some years. Greater efforts than ever will be made to clean up Bridgetown this year. The general inspection of western Charlotte county, N. B., for the brown-tail moth was completed on January 26 by Messrs. Simpson and Reed. No infestation was discovered which is the record prevailing since 1917–18.

Mr. W. A. Ross of the Vineland Station Laboratory, Entomological Branch, Canadian Department of Agriculture, attended the annual meetings of the New York State Horticultural Society which were held in Rochester on January 15, 16 and 17. Many important and enlightening discussions took place dealing with entomological problems and the exhibits of spraying materials and spraying and dusting machinery were excellent. Mr. Ross took an active part in various disscussions including the grape leaf hopper problem. Under the auspices of the Welland Reforestation Committee a meeting was held in Welland on January 23 for the purpose of discussing the matter of reforesting waste lands. At this meeting Mr. Ross discussed his work in the Pelham district and emphasized the important association of the reclamation of neglected lands in the area infested by the rose chafer to the successful control of the pest. On January 24 and 25, Mr. Ross also attended Fruit Growers' meetings in Trenton and Brighton.

Announcement has just been made of the resignation of Dr. W. E. Hinds as Entomologist at the Alabama Experiment Station. On April 1 he will take up similar work with the Louisiana Experiment Station at Baton Rouge, La. Dr. Hinds has been located at the Alabama Station since 1907. During that time he has made special study of the control of insect pests attacking stored corn. This is one of the most important insect pests in the South and through these studies ways were found for saving millions of dollars each year to the corn growing areas of the South Atlantic and Gulf Coast States. In his work with the cotton boll weevil he has been one of the pioneers, having been in that work since 1902. He is at present Chairman of the Committee on Entomology of the Cotton Production Council of the Southern Agricultural Workers and also a Representative of the Southern Agricultural Workers on the National Boll Weevil Control Association. He has been President of the Association of Cotton States Entomologists since its organization in 1910. A very successful meeting of this Association was held at Birmingham, Ala., in January, last.

Mr. William D. Richardson, an amateur coleopterist of Fredericksburg, Va., died at the State Hospital at Marion, Va., October 31, 1923, after a long illness. After his return from service in France he donated most of his collection of beetles to

the National Collection, but retained the families Elmidae and Parnidae for a study which his illness made impossible. While on a visit to friends at the Musuem he told of the material he had collected during his military service along the Mexican Border and in France and of its bequest to the National Museum by a provision of his will, but having no entomological friends in Richmond who could understand his interests, only seven boxes, probably comprising all of his pinned specimens, were preserved from the cleaning of his room during his long confinement at the hospital. J. Bowie Ferneyhough of Richmond has kindly sent these boxes to the National Museum for safe keeping pending the legal settlement, but manuscripts and notes were not found. The Richardson collection is chiefly valuable for the fine specimens of small beetles collected at Fredericksburg, Va., between 1891 and 1904.

On November 28, 1923, Dr. T. E. Snyder of the Bureau of Entomology visited the Naval Aircraft Factory, U. S. Navy Yard, Philadelphia, Pa., to outline cooperative experiments in steaming, in kiln, lumber infested with Lyctus powder-post beetles. Various temperatures from 120° to 180° F., are to be tested to determine fatal temperatures. R. A. St. George supervised these steaming tests from December 11 to 14, at the Naval Aircraft Factory. Mr. St. George visited a wood-turning factory at Front Royal, Va., to determine the results of cooperative tests to prevent attack by wood-boring insects. Dr. Snyder inspected telephone poles in the vicinity of Norfolk, Va., December 15 and 16, to determine the distribution of and extent of damage by the northern Florida termite *Kalotermes approximatus* Snyder. This nonsubterranean wood-boring termite has not yet become a pest in Virginia. Species of *Kalotermes* so extensively damage the tops of telephone poles as to necessitate impregnating the entire pole, cross arms, etc., with coal-tar creosote. Dr. Snyder left Washington on January 24 for Ancon, C. Z., Panama, where tests are to be continued with wood preservatives to protect timber from attack by wood-boring insects, especially termites. By means of an agreement with Dr. Quaintance, Dr. Snyder will be greatly aided in this work through cooperation with J. Zetek.

During the Annual Farm Products Show Week, there was an informal gathering of entomologists working within the State of Pennsylvania, at Harrisburg, Pa., on January 23, 1924. The meeting was held at the offices of the Pennsylvania Bureau of Plant Industry, and 25 entomologists were present, all excepting one—Professor P. J. Parrott of Geneva, N. Y.—being entomologists working within the State of Pennsylvania. There were represented among the gathering the Bureau of Plant Industry, the Pennsylvania Department of Agriculture, the Pennsylvania State Experiment Station, the Extension Service of the Pennsylvania State College, the Federal Bureau of Entomology, and several commercial concerns. All of the men gathered here were particularly interested in economic entomology, and included men who were primarily interested in the following phases: fruit insects, field crop insects, vegetable insects, nursery insects, greenhouse insects, apiary investigations, nursery inspection, extension in entomology, forest insects, entomological collections, and medical entomology. After the general meeting the gathering adjourned to a local restaurant for supper. After supper a short business meeting was held and it was agreed to form an organization, the name adopted being the "Entomological Society of Pennsylvania," the membership to be open to any entomological worker in the State, not limited merely to professional workers. It was further agreed that there would be an Annual Round Up in Harrisburg at the time of the Annual Farm

Products Show with field gatherings from time to time as opportunity offered. The officers chosen were C. H. Hadley of the Pennsylvania Bureau of Plant Industry as President, and S. W. Frost of the Pennsylvania State College Experiment Station as Secretary. The following entomologists were present: H. D. Smith, P. R. Myers C. C. Hill, C. F. Doucette, and J. L. King of the U. S. Bureau of Entomology; D. L. Van Dine, J. L. Horsfall, A. L. Strand, S. W. Frost, H. E. Hodgkiss and N. E. Phillips of the Pennsylvania State College; J. R. Stear, T. L. Guyton, Fred H. Worsinger, Jr., G. B. Stichter, F. M. Trimble, A. B. Champlain, A. B. Wells, F. L. Holdridge, H. B. Kirk, C. N. Greene and C. H. Hadley of the Pennsylvania Bureau of Plant Industry; T. T. Haack and J. K. Primm of the Sun Oil Company; and P. J. Parrott of the Agricultural Experiment Station, Geneva, N. Y.

A conference of North Central States Official Entomologists was held at the Ohio State University, Columbus, Ohio, March 6 and 7, 1924. This conference was for the purpose of correlating the research and extension programs in the north central states. Projects in progress, or to be undertaken, were discussed. The European Corn Borer program was of most general interest of the topics under discussion. Plans for investigation and control work in Ohio were discussed. Entomologists of the States of Ohio, Indiana, Illinois and the Bureau of Entomology will unite to carry out an intensive corn borer clean-up campaign. This will be made in northern Ohio counties April 14 to 26. Among other subjects discussed were: Hessian fly and chinch bug problems, oil emulsions, cyanide and nicotine dusts, potato leafhopper control and the Mexican bean-beetle. H. A. Gossard was chosen Chairman and T. H. Parks Secretary of this meeting. The following entomologists were present: *Ohio:* D. M. DeLong, Richard Faxon, H. A. Gossard, J. S. Hine, J. S. Houser, L. L. Huber, C. H. Kennedy, R. C. Osburn, T. H. Parks; *Indiana:* J. J. Davis and F. N. Wallace; *Illinois:* W. P. Flint; *Wisconsin:* E. L. Chambers; *Michigan:* R. H. Pettit; *U. S. Bureau of Entomology:* E. G. Brewer, D. J. Caffrey, Geo. A. Dean, W. H. Larrimer, F. W. Poos, G. A. Runner, A. F. Satterthwait, L. H. Worthley; *Graduate Students at the Ohio State University:* S. W. Bilsing, J. W. Bulger, C. R. Cutright, W. S. Hough, J. N. Knull, H. C. Lewis, C. R. Neiswander and A. N. Tissot.

Dr. J. F. Illingworth, formerly professor of entomology in the University of Hawaii, after spending four years in Australia on a special investigation of the pests of sugar cane for the Queensland Government, returned to his home at Honolulu. There he was appointed research associate in entomology at the Bishop Museum, which is his permanent address. At present Dr. Illingworth is engaged as specialist on the Green Japanese Beetle problem, by the U. S. Department of Agriculture, and is traveling in the Orient. The past season was spent in a general survey of this pest in Japan, where, unfortunately, he lost all his equipment in the Yokohama catastrophe. Since Dr. Illingworth is to investigate Chinese territory during the coming season, he has selected Shanghai as temporary headquarters, care of the American Consul.

Notes on Horticultural Inspection

Mr. Chester A. Davis, Plant Quarantine Inspector at Philadelphia, has been transferred to Boston, reporting for duty on March 10.

Mr. C. W. Stockwell of the Japanese Beetle Laboratory at Riverton, N. J., was called to Washington for a conference on March 1.

A live Alfalfa Weevil, *Phytonomus posticus* (Gyll.), was taken recently in packing material from a registered package coming from Germany, by Mr. George Compere in San Francisco.

Mr. William W. Chapman, a recent graduate of the Mississippi State Agricultural and Mechanical College, has been appointed to the position of Plant Quarantine Inspector, with headquarters at Philadelphia.

Dr. Norman Perrine of the Washington force has just returned from a trip to Boston, where he was making tests of the efficiency of gas generating apparatus used in cotton fumigation.

Mr. J. A. Stevenson has returned from Cuba, where he made an investigation of the potato disease on the Island to determine the advisability of permitting the shipment of potatoes to the United States.

Mr. William V. Reed, formerly State Entomologist of Georgia, has been appointed to the position of Plant Quarantine Inspector with headquarters at New Orleans, La. He took up the work at that Station on March 10.

Mr. A. G. Albrecht, a Plant Quarantine Inspector of the Federal Horticultural Board, has been transferred from New Orleans to Philadelphia to take up the duties formerly performed by Mr. Chester A. Davis, who was transferred to Boston.

The Spiny Citrus White Fly, *Aleurocanthus woglumi* Ashby, has been intercepted on Spice leaves from Nassau, Bahamas, and on Citrus from Cuba. The latter interception was made at Jacksonville in a registered mail package destined for Ashville, N. C.

Mr. Thomas J. Baker, formerly a Quarantine Inspector of the State of Florida and recently Plant Quarantine Inspector for the Federal Horticultural Board at New Orleans, has been placed in charge of the inspection work at Astoria, Oregon.

Messrs. J. A. Stevenson and W. T. Owrey of the Washington office recently completed an inspection trip to points in Florida and Georgia. They visited several field stations of the Bureau of Plant Industry and inspected all plants intended for distribution.

A species of *Balaninus* has been frequently taken at the Inspection House in shipments of Chestnuts and *Castanopsis* sp., arriving from China. This insect is similar in appearance to the smaller Chestnut Weevil, which is common in this country.

Mr. William F. Freeman, who has been in charge of the port of Astoria, Oregon, has been transferred to New York. Mr Freeman will have direct charge of the inspection work in New York City under the supervision of Mr. Shaw.

Mr. Alva C. Hill has been appointed to the position of Plant Quarantine Inspector

with headquarters in New York City. Mr. Hill is a graduate of the Missouri Agricultural College and has taken graduate work at the Iowa State College of Agriculture.

Mr. Randolph W. Nicaise has been appointed Plant Quarantine Inspector in the Federal Horticultural Board with headquarters at New York. Mr. Nicaise was formerly employed by the Bureau of Entomology in Boll Weevil work and later by the Federal Horticultural Board in the Pink Boll Worm Eradication work.

A Scolytid beetle, *Coccotypes* sp., has been taken recently in several lots of palm seeds received at Washington for inspection, which were destined for points in the South. The beetle works as a stored product pest, entering the seeds from the outside and breeding and feeding within the kernel.

Mr. J. T. Rogers, in charge of the inspection work at Charleston, S. C., recently intercepted the Turnip Gall Weevil, *Ceutorhynchus pleurostigma* Marsh, in turnip roots from Newcastle, England. This insect is treated in a paper published by P. B. Isaac in the "Annals of Applied Biology," Vol. 10, 1923, page 170.

Mr. Thomas A. Arnold, Plant Quarantine Inspector at El Paso, in making an examination of the bedding carried by a Mexican coming across the Border into Texas, found the larva of an insect crawling on the outside of the roll. The larva was determined by Mr. Heinrich of the Bureau of Entomology as the Pink Boll Worm.

Dr. William Mann of the Bureau of Entomology left Washington the latter part of January *en route* to Colombia, South America, in the interest of the Federal Horticultural Board. He will make an investigation of the insects liable to be imported into the United States, which attack fruits and vegetables, paying particular attention to the fruit flies. From Colombia, he will proceed northward, passing through Panama and into the Central American States.

A package of cotton from Hawaii addressed to a firm at Calexico, Calif., was turned over to Mr. O. A. Pratt, Plant Quarantine Inspector at that point, immediately upon its receipt by the firm. Mr. Pratt writes that while the seed showed abundant evidence of insect injury, he was able to find only one live larva, which he cyanided and sent to Washington. The insect was determined by Mr. Heinrich as the Pink Boll Worm.

Apicultural Notes

The California State Beekeeper's Association held its 33rd annual meeting during holiday week at Sacramento.

The short course on beekeeping at the Agricultural College, Fargo, N. D., was given in February. From 15 to 25 attended.

Mr. J. I. Hambleton, Bureau of Entomology, was one of the speakers at the meeting of the Pennsylvania State Beekeeper's Association at Harrisburg, Pa., January 24 and 25.

Dr. E. F. Phillips will represent the Apiculture Section of the Association of

Economic Entomologists at the Seventh International Apicultural Congress to be held in Quebec, September 1 to 4.

A short course and conference for Indiana beekeepers was held at Purdue University, February 11–14. Among the speakers were Dr. E. F. Phillips, Geo. S. Demuth and Professor John J. Davis.

The first step in the formation of a permanent beekeeper's association in Arkansas was taken on February 11 when the new organization was completed. George G. Becker, of Little Rock, was chosen secretary.

The annual meeting of the Ohio State Beekeeper's Association was held at the Ohio State University, Columbus, February 7 and 8. F. B. Moore was elected President and Miss Florence Naile, Columbus, Secretary-Treasurer.

The proceedings of the Sixth International Apicultural Congress held at Marseilles, France, September, 1922, have at last appeared. All papers are given in French and copies may be had from the Secretary of the Congress, Léon Tombu, 185, rue Gaucheret, Brussels, Belgium.

A new bee journal has made its appearance and is called the "Midwest Farm Beekeeper." J. W. Kuhn of Belleville, Kansas, is the Editor. According to the Editor, its field is "the Great Central West from the Mississippi to the Mountains and Beyond."

The Tennessee Beekeeper's Association held its annual convention at Nashville on February 1, over 100 being in attendance. This was one of the best meetings the association ever held. Mrs. Grace Allen, Nashville, was elected President and Professor G. M. Bentley, Knoxville, was reëlected Secretary-Treasurer.

Professor F. B. Paddock, State Apiarist of Iowa, is scheduled for two radio talks from the Ames Station, WOI, 360 meters. These talks will be given at 12:40 noon, with dates and subjects as follows: March 28, "Spring Care of Bees," May 23, "Preparations for the Honey Crop."

The fifteenth annual meeting of the Maryland State Beekeeper's Association was held in the Southern Hotel, Baltimore, on January 9. Addresses were made by Dr. E. F. Phillips and J. I. Hambleton of the Federal Bureau of Entomology, and by M. W. James, Baldwin, Md., and George Harrison Jr., University of Maryland.

The annual meeting of the Kansas State Beekeeper's Association was scheduled to be held at Topeka, February 4 and 5, then adjourn to meet on the 6th and 7th at the apiary department of the Agricultural College at Manhattan. Mr. O. F. Whitney, Topeka, is the secretary of this association.

A gathering of Fargo, N. D., beekeepers was held February 15. Mr. L. T. Floyd of Winnipeg, who was in Fargo to give lectures at the short course at the Agricultural College, told about the recent beekeeper's meeting of the Manitoba association, and Mr. O. F. Miller related some of his observations on California beekeeping.

Mr. R. B. Willson, Extension Specialist for New York State, broadcasted a talk on the uses of honey from Station "WEAF," New York City, on the evening of February 27. During the course of his talk he mentioned Farmers' Bulletin 653, "Honey and Its Uses in the Home" and since that time has been overwhelmed with requests for the bulletin.

Dr. F. Vincens has been appointed by the French Government to investigate the diseases of bees in that country, especially those of the adult bee. The laboratory for

this work has been established at Cagnes, Alpes-maritimes, in southern France. Dr. Vincens has recently published two short papers in the *Comptes rendus* of the Paris Academy of Sciences on two fungi which appear to be pathogenic to adult bees.

At the annual convention of the American Honey Producers' League, held in Chicago on January 24 and 25, Mr. B. F. Kindig, chief apiary inspector of Michigan, was elected president and Mr. Colin P. Campbell of Grand Rapids, Michigan, as vice-president. The executive committee re-appointed S. B. Fracker, Madison, Wisconsin, as secretary.

Dr. M. C. Tanquary, Chief of the Division of Entomology, Texas Agricultural Experiment Station, and State Entomologist, has resigned, effective May 1, to enter a commercial apiary business extending into several states. He has held this position in Texas for four years, preceding which he was Assistant Professor of Entomology at the Kansas Agricultural College and Assistant Entomologist of the Experiment Station. Dr. Tanquary is automatically succeeded by H. J. Reinhard, who has been a member of the staff for more than eight years.

In connection with Farmers' Week at Ames, Iowa, a beekeeping short course was given under the direction of Professor F. B. Paddock. Outside speakers included G. H. Cale, of Hamilton, Illinois, who gave several talks on general beekeeping methods; S. B. Fracker, of Madison, Wisconsin, who spoke on marketing, on bee disease eradication, and on the work of the American Honey Producers' League; and Professor Francis Jager, St. Paul, Minnesota, who discussed the subjects of queen rearing cellar wintering, and European beekeeping.

Mr. Willis J. Nolan of the Bureau of Entomology returned January 31 from his European trip. While abroad he visited the newly established apicultural experiment station of the Republic of Czecho-slovakia, located at Prague, and in charge of Dr. A. Schonfeld. The station is located in the suburbs of the city and occupies a large estate with excellent buildings. The work is just being begun and will include a study of the diseases of bees in that country. He also visited Vienna where he spoke before one of the beekeeping societies of the city and met a number of the prominent beekeepers. He also visited the Bakteriologische Anstalt at Liebefeld near Bern, Switzerland, where Dr. Robert Burri who worked on bee diseases some years ago is director. The bee disease work there is now in charge of Dr. Otto Morgenthaler. Mr. Nolan did not go into Germany as he had planned because of the disturbed economic conditions of that country.

Federal cooperation with the states in an extensive American foulbrood eradication campaign on the area cleaup method will be asked of Congress by the American Honey Producers' League, according to action taken at the annual convention. A steering committee, consisting of B. F. Kindig, chairman, S. B. Fracker and E. R. Root, and two others yet to be appointed, has been organized to sponsor the campaign and a large federal appropriation will be asked for the purpose. It is understood that the work will be done county by county and state by state in accordance with the successful area clean-up campaigns now in progress in several states, and that the areas freed from disease would be protected from the introduction of infected material by federal authority. The promise of the active support of the United States Department of Agriculture is assured, according to Dr. E. D. Ball, who has discussed the subject in several public addresses and personal conferences, and the project is also advocated by the Bee Culture office of the Bureau of Entomology.

Pacific Slope Notes

Dr. William Moore of the American Cyanamide Company visited southern California after the Cincinnati meetings, returning to New York via New Orleans and Washington.

Mr. Neguil Iskander, Assistant Entomologist in the Ministry of Agriculture, Cairo, Egypt, spent several weeks in California, investigating methods of insect control. He was particularly interested in fumigation with liquid hydrocyanic acid gas.

Mr. A. J. Flebut, who has been in charge of the Citrus Thrips Project, with headquarters at Lindsay, Calif., has resigned, effective January 1, 1924, to accept a position with the General Chemical Company, San Francisco. It is understood that he will have charge of the insecticide department of this company, succeeding the late S. W. Foster.

Notes on Medical Entomology

Professor Herbert Osborn, of Ohio State University, is spending a few weeks visiting in southern California. Recently the entomologists at the Citrus Experiment Station at Riverside, Harold Compere, A. J. Basinger and Harry S. Smith, arranged a collecting trip for Professor Osborn and Professor Lawrence Bruner to Palm Springs Canon in the Colorado Desert. Collecting was rather poor owing to the abnormally dry season, but some interesting species were secured.

According to the *Official Record*, Dr. W. V. King in charge of investigations of insects affecting the health of man at Mound, La., has experimented in dusting swamps with an airplane to kill mosquitoes. The dust consisted of Paris green heavily diluted with Tripoli earth, and similar materials have been recommended in certain cases by the United States Public Health Service. The airplane offers simply a wholesale method of application, and proved very successful.

Professor H. J. Quayle, of the Citrus Expermiment Station at Riverside, California, has returned from a trip around the world. Professor Quayle carried on some interesting demonstrations of the use of calcium cyanide in Australia for control of the red scale of citrus. He also demonstrated the use of this material for control of the rabbit plague in that country, where it gives promise of much success. Some time was spent in Spain in an investigation of citrus insects and arrangements were made for the Spanish Government to secure beneficial insects from California, through Dr. L. O. Howard and Harry S. Smith.

The eleventh annual meeting of the New Jersey Mosquito Extermination Association was held at the Hotel Traymore in Atlantic City, February 13, 14, and 15, 1924. Dr. L. O. Howard, Chief of the Bureau of Entomology, U. S. Department of Agriculture, gave an address on some recent developments in anti-mosquito work and Major Joseph Le Prince, Senior Sanitary Engineer, U. S. Public Health Service, gave an excellent account of the anti-mosquito work in the South. The New Jersey State Federation of Women's Clubs of 40,000 members was represented by Mrs. Clayton B. Lee, Mrs. Bertha H. Boynton and Mrs. Charles A. Prickett. Dr. Jacob G. Lipman, Director of the New Jersey State Experiment Station, gave a review of the anti-mosquito legislation and an account of the present attempt to repeal all mandatory state laws. Inasmuch as the collection of funds for mosquito elimination

work in New Jersey is mandatory on the county free-holders, he urged that immediate steps be taken to prevent the passage of such an act. An interesting paper on the influence of various substances as attractive and repellent agents upon behavior of mosquitoes was presented by Dr. William Rudolfs of the New Jersey Experiment Station. Papers were read covering the progress of anti-mosquito work in New Jersey, Connecticut and New York. Ten counties in New Jersey engaged in anti-mosquito work were represented as follows: Atlantic, Fred A. Reiley and Hubert Somers; Essex, James E. Brooks and Abram H. Cornish; Passaic, Frank Wilkinson; Bergen, Alfred J. Tipping; Hudson, Lewis E. Jackson; Union, Louis Richards; Middlesex, William Dinwiddie; Monmouth, Dr. G. Van Voris Warner; Ocean, Robert F. Engle; Cape May, Alan de P. Ewing. A paper by Robert C. Botsford on the Connecticut work was illustrated by lantern slides. Mr. William De Mott presented a paper on the anti-mosquito work in Nassau County, Long Island. The subjects of oiling, larvicides, ditching and ditch cleaning, machinery, education in public schools, legislation and others were discussed and illustrated. The convention was well attended and thoroughly interesting and instructive.